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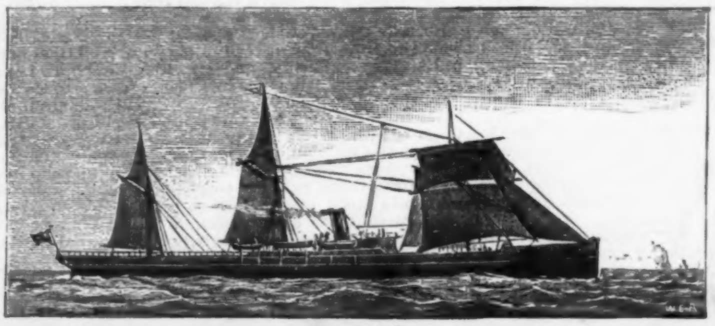
MERCHANT VESSELS AS ARMED CRUISERS.

RECENTLY, when war with Russia appeared imminent, the British Government decided to take up a number of merchant steamers, and, placing them in the hands of naval artificers, arm and fit them as cruisers. Besides carrying ten heavy guns, each ship of the mercantile marine chartered by the Government for cruising purposes is to be provided with several Nordenfeldt guns. More than fifty vessels belonging to our magnificent merchant fleet have thus been taken over by the Government for equipment, and they will add considerably to our naval strength.

The following vessels, which appear in our engravings, have been chartered from the Peninsular and



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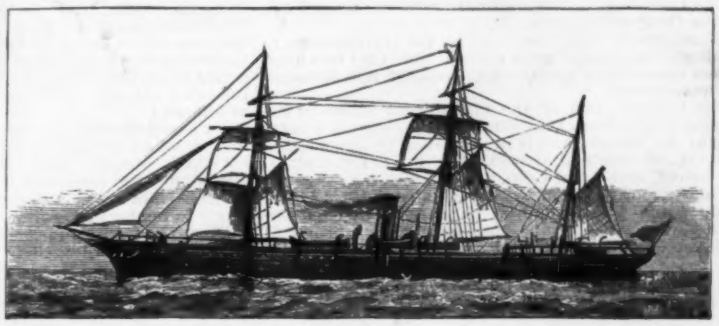

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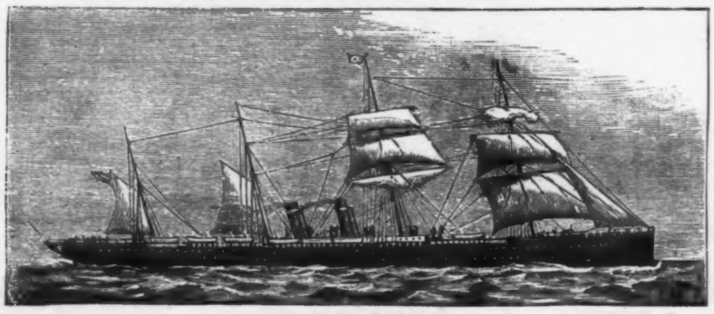

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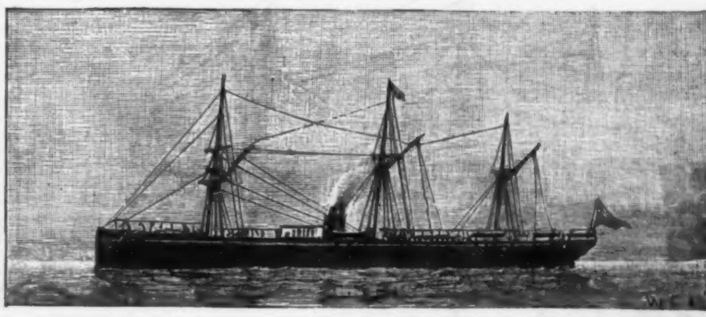

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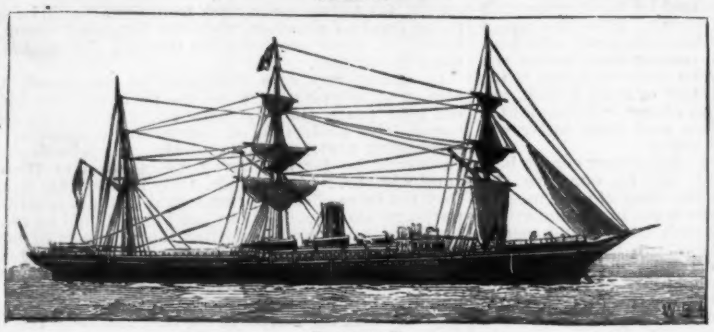
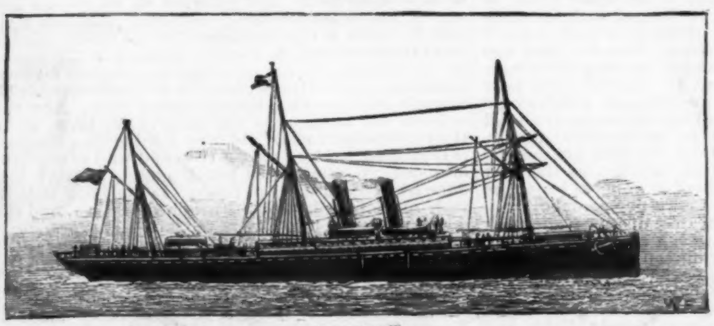


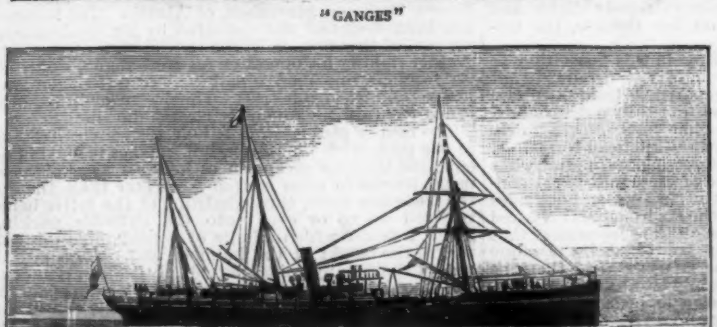
"POONAH"

"NEPAUL"



"GANGES"

"GEELONG"



"ROSETTA"

"UMBRIA" AND "ETRURIA"

FAST STEAMERS TAKEN BY THE BRITISH GOVERNMENT TO BE USED AS ARMED CRUISERS IN THE EVENT OF A WAR WITH RUSSIA.

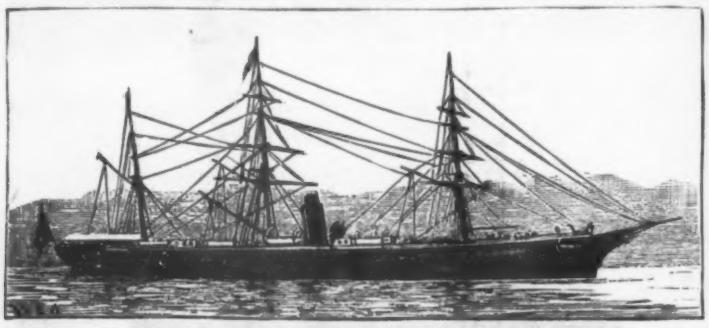
Oriental Company: The Rosetta was built in 1880 by Messrs. Harland and Wolff, of Belfast. She is 390 feet long, 40 feet broad, of 3,501 tons register, and 700 nominal horse-power. The Ganges, now stationed at Saukim as a hospital ship, was built in 1882, of steel, by the Barrow Shipbuilding Company. She is 390 feet long, 42 feet broad, of 4,195 tons register, and 800 nominal horse-power. The Australia, built by Messrs. Caird and Co., of Greenock, is 365 feet long, 44 feet broad, of 3,663 tons register, and 600 nominal horse-power. The Zambesi, built by Messrs. Barclay, Curle, and Co., is 330 feet long, 36 feet 6 inches broad, of 2,430 tons register, and 370 nominal horse-power. The Poonah, built by the Thames Iron Works Company, is 395 feet long, 41 feet 8 inches broad, of 3,130 tons register, and 550 nominal horse-power. The Khiva, built by James Laing and Co., of Sunderland, is 360 feet long, 36 feet 6 inches wide, of 2,608 tons register, and 450 nominal horse-power. The Geelong was built by Messrs. Denny Brothers. She is 264 feet long, 34 feet broad, and of 250 nominal horse power. Of the Nepaul, no details have reached us.

The Mexican, belonging to the Union Steamship Company (Cape of Good Hope Royal Mail line), was built by James Laing and Co., of Sunderland. She is 378 feet long, 47 feet broad, has a gross tonnage of 4,668, and engines of 600 nominal horse-power.

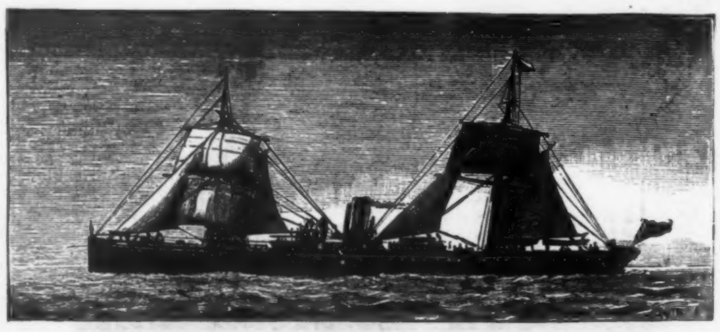
The Lusitania, belonging to the Orient Steam Navigation Company, is being fitted out in Sydney Harbor. She has already been employed by the Government in the Egyptian Campaign of 1882-83. She is 384 feet long, 41 feet broad, has a gross tonnage of 3,832, and 550 nominal horse-power.

The Umbria, one of the magnificent steamers belonging to the fleet of the Cunard Company is a sister ship to the Etruria, and is built of steel by John Elder and Co., of Fairfield, Govan. She is 520 feet long, 57 feet broad, and 41 feet deep.

The Arizona is one of Messrs. Guion and Co.'s Atlantic fleet, and is built of iron in water-tight compartments. The Arizona is 465 feet long, 46 feet broad, 37 feet deep, and close on 6,000 tons burden. Her main deck is 400 long. To this line belongs the Alaska, surnamed the "Greyhound of the Atlantic." She has made the passage from New York to Queenstown in six days 18¼ hours.—*The Graphic.*



"LUSITANIA."



"KHIVA."

FAST STEAMERS TAKEN BY THE BRITISH GOVERNMENT TO BE USED AS ARMED CRUISERS IN THE EVENT OF A WAR WITH RUSSIA.

TORPEDO BOATS IN WAR.

One of the most astonishing phases in the efforts that are at last being made to increase the efficiency of the Royal Navy is the utter neglect of large torpedo boats. There are now eighteen first-class torpedo boats in course of construction, or rather eighteen have been ordered, the value of these vessels being about equivalent to that of one quarter of an ironclad. The reason for this neglect may be that the value of this class of vessel for warlike purposes is not appreciated thoroughly, and that their advantages have not been properly urged; for though many have argued generally that torpedo boats are necessary, and that no fleet can keep the sea in the presence of a flotilla of them, etc., these generalities do not bring the subject home with sufficient force, and their construction is only regarded in the light of a possible contingency that may have to be looked into some of these days when there is more time, meaning, probably, when we shall have had a practical proof of their power by having some of our ships destroyed by them. Let us, then, examine this matter closely, and consider the case of two antagonistic powers, the one possessing a powerful flotilla of torpedo boats, the other a large fleet of ironclads. Perhaps nothing would illustrate the case better, and certainly nothing would tend more to bring matters home to us now, than to make this comparison personal, and say that England is the power with the ironclad fleet, while Russia is the possessor of the torpedo boat flotilla. We will imagine that we are at war with Russia—no very great stretch of imagination will be required for this—and that our fleet are going to do something, it is really very hard to say what; but it being generally understood that they are to go up the Baltic, probably the idea will be to try and keep the Russian fleet from getting out. We will say that it is so for argument's sake, as that is really all they can do, or rather try to do. Now how would they set about it? They must blockade, of course. Very well, then, we will imagine our Baltic fleet of say twenty ships spread out in line at night, covering, perhaps, a length of fifteen miles. They doubtless will have their torpedo nets down (at least those that possess them, which will probably be about half); a cordon of torpedo boats will probably be placed well inside them, in the proportion of two boats to every ship, half of these boats being second-class torpedo boats and the other half steam pinnaces; men will be stationed at the guns, especially the machine guns, the maximum number of which, by the way, on board of any of the ships is twelve, and ships possessing this number are the exception; the electric light will be kept going, in fact everybody will be on the alert, and everything will be done that can possibly be done to guard against surprise, and to render futile any hostile attack of torpedo boats.

Now let us turn to the other side, and imagine what the Russians would be about. The movements of our fleet would be well known, for it is not likely that they would remain in ignorance of them when they possess first-class torpedo boats capable of steaming 22 knots, when our fastest vessel can only steam 17.

The exact position and movements of our squadron being known, and Russia having forty or fifty first-class torpedo boats available for service, the next thing is for them to proceed to worry the ironclads. Thirty boats are accordingly prepared, a dark night selected, and half a dozen ships of the blockading line selected as points of attack. These thirty boats then get as close up to the line of guard boats as they can without being discovered, and as soon as they are sighted they make straight for the selected ships, which will of course be obligingly marked out for them by the electric light. Now, nobody can for one moment suppose that the guard boats can stop the advancing torrent, for the Russian vessels are all larger than they are, of greater speed, and further possess the advantage of having to be caught. The only thing for the guard boats to do is to endeavor to disable them with hand charges; and seeing that there can only be two guard boats to every three-quarters of a mile, and that the assailants have the speed, it appears very unlikely that the latter will venture within range (20 yards) of these weapons. Once past the line of guard boats they are clear, for, even if the latter *could* overtake them, they dare not follow them up for fear of masking the fire of their own ship's guns, and therefore the duties of these guard boats must be limited to giving warning of the intended attack. The situation now resolves itself as follows:

Six ironclads, with six minutes to prepare in, have to withstand an attack of thirty first-class torpedo boats, for which purpose they have their heavy guns, machine guns, and torpedo nets. Now, let us examine these defenses minutely, and see what assistance they are likely to render in warding off the attack.

First, the heavy guns. The only way in which these can be effectively used is by being loaded with case shot laid horizontal, concentrated by bearing for 1,000 yards (say), and fired by electricity from the upper deck when any boat or boats have advanced sufficiently close. Any torpedo boat coming thus within the zone of fire would probably be destroyed; but if the assailants make a combined bow or stern attack, the heavy guns, with the exception of one or two mounted forward or aft, will be useless, and these latter will have to take their chance of hitting.

Secondly, the machine guns. Some very comprehensive trials have been carried out by our own and foreign governments to test the effect of machine-gun fire against models of torpedo boats in day-light; but we have neaver heard of any such trials being carried out at night. Hence, we are quite in the dark on this point; but judging from the results of the day trials, there appears to be little probability of the machine guns hitting at all at night. In the first place, the sights cannot be seen; secondly, if they could be seen, there would probably be a great difficulty in seeing the object to be fired at; thirdly, if the object could be seen, its distance could not be judged with the accuracy necessary to make the striking of such a small target a certainty, and not seeing where the shot was going, there would be no means of knowing if you were firing over, under, right, or left; fourthly, the boat would be moving at a high rate of speed, which would render hitting difficult at any time, and make it almost impossible to keep the sights on in the dark; fifthly, supposing the boat were struck, the odds are against its being struck in a vital part; sixthly, as the boat would be moving at the rate of 20 knots at least, she would only be under fire for twenty-five seconds if advancing from 500 yards (the nearest distance at which she could be distinguished on even an averagely dark night) to close alongside, or fifteen seconds to a 200 yards' range, when the Whitehead torpedo might be discharged. It may, then, fairly be concluded that the chances of the five torpedo boats being destroyed before firing their torpedoes are extremely slight, and so we pass on to the third and last defense, the torpedo nets.

Experiments are not wanting in this case either to show that the present system of net defense is not efficient against a properly prepared torpedo boat, and that it is always liable to be forced by a determined attack, though at the same time nets offer a fairly effective barrier to one or two Whitehead torpedoes. Of course, it is absolutely impossible to predict what would be the result of any one of these individual contests, but supposing we take the chances on both sides as being equal, three out of the six ironclads attacked would be destroyed. This is on the supposition that the ironclads are effectually protected by machine guns and nets, especially the latter; should these be inefficient, the odds are certainly two to one on a determined attack by a single torpedo boat being effective. To put this personally and drive it home, certainly not half the ships which are to form the proposed Baltic fleet are efficiently protected, either with guns or nets, and therefore we consider it a certainty that out of half a dozen ships attacked in force, three or four at least must be sunk or disabled. Perhaps half a dozen torpedo boats might be sunk in the attempt, but what of that. Sixty of these at least could be built for the price of one ironclad, and then the moral effect. The men in a torpedo boat start with the full knowledge that their lives are in their hands, and that should they succeed, they will be covered with glory, and should they fail—why, there will be plenty more willing and eager to take their places, while the crew of an ironclad can do nothing to ward off the attack. Some twenty or thirty men are employed about the machine guns, while the others can only sit still, and hope the nets may not be forced. Imagine the feelings of the crew of an ironclad, after one of their ships had been sunk by a torpedo in a night attack. As the night advanced and the time came to go to rest, will they not each be haunted by the idea that at any moment a torpedo may be exploded immediately under his particular resting place, and that the different members constituting his frame may be scattered in divers directions? It is an unpleasant thing to be stabbed in the back, and if you happen to be in the neighborhood of a place where such things occur, it will be a small consolation to you to know that there are police about ready to arrest the assassin if they can catch him. We can easily imagine such a state of mind being that of a torpedo-worried crew, and that some nerves would become strained to such a tension that a panic might at any moment be expected.

So much for ironclads against torpedo boats. Now, let us imagine that instead of expending all this energy in building, repairing, and patching ironclads, the attention of the authorities had been directed to the construction of torpedo destroyers, of from two hundred to three hundred tons, and that a mixed fleet of these and other torpedo boats had been sent up the Baltic to intercept the Russian cruisers. They have nothing more to fear from the torpedo boats than the torpedo boats have from them, as far as torpedo discharge is concerned, while their armaments of rapid-firing guns, combined with their great speed, would enable them to destroy their smaller opponents. They would be just as effective as an ironclad fleet, for all the purposes required, for a combined attack from them would be safe to be fatal to a cruiser, while the latter, by reason of her speed, would probably slip through the fingers of the ironclad fleet.

In almost any case that may be considered, the attack of shipping in a hostile port, the defense of our own ports, the destruction of the enemy's commerce, the protection of our own commerce, or blockading ports, a flotilla of these torpedo destroyers would be far and away more effective than a cumbrous fleet of ironclads. Only in one case would they not be as effective; that would be for bombarding purposes, and alas, that our last hope should be taken from under us! We greatly fear that the days of bombarding are over, and that mines and torpedo boats would prevent a fleet ever getting within range of a hostile port, unless, indeed—and here is a spark of hope—we could get another Alexandria. Now, can anybody look the matter in the face, and deny the undoubted necessity of a powerful torpedo fleet, such as we have described? And yet what do we see and hear of? A fleet of inadequately protected ironclads being sent to make a demonstration in the Baltic—though what they are to demonstrate, unless it be their liability to attack, we are at a loss to see—and eighteen first-class torpedo boats *going to be* constructed. The torpedo destroyers are not mentioned even. Now that w have the bulldogs of war close at our heels, we see the prophecies of many able men coming true, the panic is beginning, and we have a rush and wild expenditure of money to attain that which ought to have been done leisurely in times of peace. Let us hope that the rush and expenditure *will* attain the object, and that it will not again be a case of too late.—*Engineering.*

IMPROVED STEAM HAMMER.

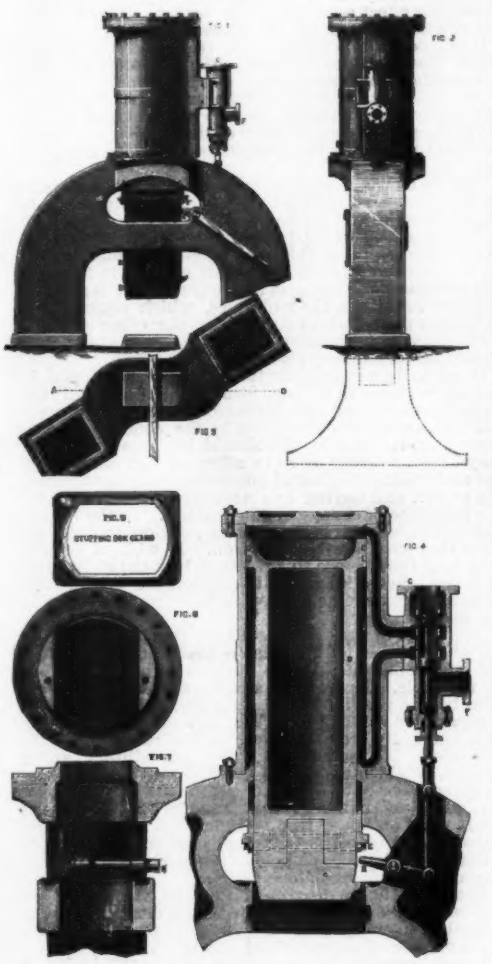
The accompanying engraving represents a type of steam hammer of which a series is being made by Messrs. Dick and Stevenson, of Airdrie. The hammer has been designed and patented by Mr. Graham Stevenson, of that firm, with the special view of securing greater rigidity for operation on steel ingots and steel use forgings, now increasingly replacing the older malleable product of this class. The design embraces several novel features which are clearly shown.

The ram or piston bar is a hollow steel casting, and in one piece with the piston, but in place of having an enlarged head for reception of hammer face piece as usual, its size in cross section is greater than that of the face piece itself, thus admitting of the latter being traveled up to or even into the cylinder packing gland, a device which admits of considerable diminution in the height of the hammer, and secures steadiness of the ram by guides placed only sufficiently above the piece in process of hammering to afford freedom for its proper handling. It also provides for the insertion or withdrawal of the piston to or from its position through the cylinder without removal or disjointing any part except the top cylinder cover.

The anvil block and cylinder-supporting standards, the latter being preferably cast of steel, are in two castings, but being keyed together are rendered virtually of one mass, resting on one foundation, and op-

posing joint resistance to the ram blows. By this union of the two main members all chance of variation in relative position is entirely provided against, a point which will be appreciated by hammer users.

The illustration shows that the designer has aimed at the employment of few bolts, few joints, and generally few opportunities for slackness, flexibility, or derangement. The first of the type, a small sized hammer with three ton ram, was put under steam at the Crown Ironworks, Coatbridge—Messrs. William Tudhope and Sons—a few weeks ago, when its behavior at work greatly pleased those concerned. The hammer face is oblong as usual, and the two annexed illustrations, Figs. 1 and 2, show the legs of standard placed in the lengthways plane of the hammer face and anvil block, but in hammers intended for use forgings, the legs are placed obliquely to the plane of the hammer, as represented by the plan, A, B, Fig. 3, in order to give more convenient access in applying sets or cresses to pieces submitted to hammering action. The engravings, Figs. 4, 5, 6, and 7, give the constructive information not to be gathered from the foregoing views, and show to what a simple thing the valve gear of a steam



DICK & STEVENSON'S STEAM HAMMER.

hammer has arrived as compared with Nasmyth's gear of thirty years ago. The letters in the details refer to the same parts as those in the general views.—*The Engineer.*

AMATEUR MECHANICS.

LENS MAKING.

To make an ordinary lens requires a certain degree of manipulative skill, but when compared with a fine job of filing, fitting, or even turning, it is easy, and there is a charm about making a nicely polished lens which is not found in metal working. The tyro should commence with small plano and double convex lenses, which he may mount singly or in pairs. After attaining a fair proficiency in making these, he may proceed to larger work, and afterward by coupling study with practice he will be able to make fine work, such as the achromatic objectives of microscopes and telescopes, eye-pieces, lantern objectives, etc.

The first thing to be done in the way of the preparation of tools for lens grinding is to make gauges or patterns with which to gauge the convexity of the grinding tools. These may be made from pieces of sheet brass about one thirty-second inch in thickness, the plates for gauges for convex tools being chucked on a plane board secured to the face plate of the lathe, and the circular aperture turned out. The plate should be beveled each way from the aperture, forming a knife edge, and it should be separated by a saw into two or four parts, according to the size of the lenses to be ground, as shown in Fig. 1. The radius of the circle so formed will be approximately the focus of a double convex of this curvature, and the diameter of the circle is approximately the focus of a plano-convex lens of the same curvature.

Gauges for concave tools or concave lenses are made by turning disks of brass with V-shaped edges, as shown in Fig. 2, and an instrument for shaping small concave grinding tools is shown in Fig. 3. It consists of a sharpened steel disk attached to or formed upon the end of a bar, and used as a scraper, for giving the final shape to the concave grinding tools.

For grinding convex lenses it is well to have two concave tools like that shown in Fig. 4. This as well as other grinding tools for small work should be made of brass. Drawn brass is preferable, as it is usually better metal, and more homogeneous than castings, and needs no external turning.

Having determined on the focus of the lens to be ground, the brass is chucked in the lathe, and hollowed out as nearly to the correct form as possible, the gauge shown in Fig. 2 being used from time to time to determine when the proper concavity is reached. The grinding tool is finally scraped with the cutter shown in Fig. 3. The counterpart of the concave tool shown in Fig. 5 is now turned as nearly to the gauge shown in Fig. 1 as possible, and is finally ground into the concave tool with washed flour emery and water.

A tool like that shown in Fig. 6 is necessary for finishing small lenses. It consists of a cylindrical piece of brass, having a chamber turned in the end for the reception of a mixture of pure hard beeswax and fine rouge. This mixture should contain sufficient rouge to make it rather hard, but not so hard as not to yield under strong pressure.

The glass for small lenses may be clipped from bits of plate (crown) glass and roughly shaped by means of an ordinary pair of pliers. It may then be cemented with pitch to the end of a round stick, as shown in Fig. 7. The glass is then ground on a common grindstone until it approximates the required shape. It is then polished with fine emery and water in one of the concave brass tools until a truly spherical surface is secured. It is then transferred to the other brass tool, and ground with fine washed flour emery until the surface is fine and entirely free from scratches. During the grinding as well as polishing the stick to which the glass is cemented must be turned axially, and at the same time its outer end must be moved about the prolongation of the axis of the grinding tool so as to present the glass to every portion of the grinding tool as nearly as possible.

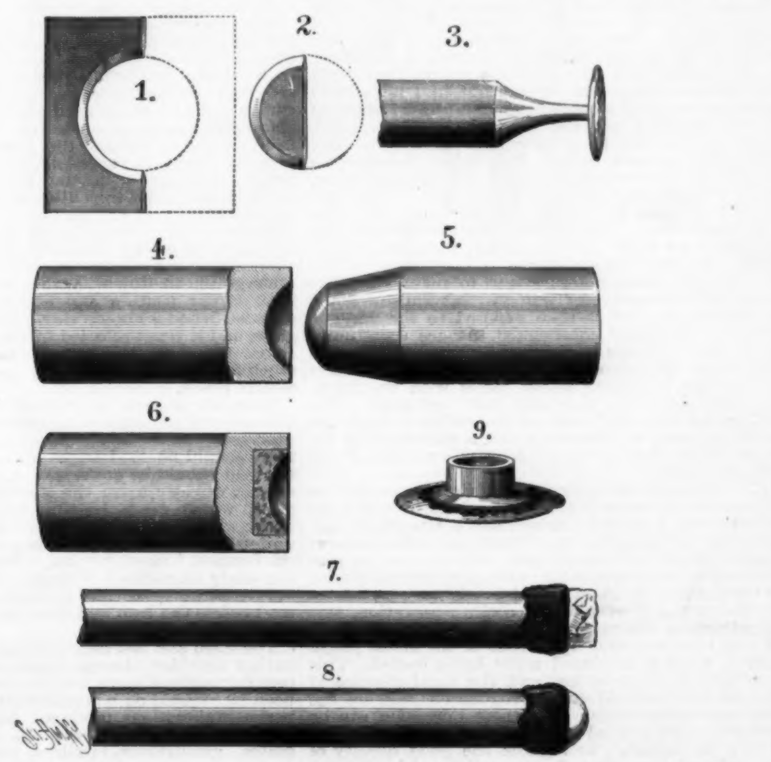
The final polish is secured by pressing the smoothed glass into the wax in the end of the tool shown in Fig. 6, as the tool is revolved, and at the same time applying fine rouge and water from time to time. When the polish is nearly perfect, the tool should be allowed to work nearly dry.

For a plano convex lens the plane surface of the plate glass will answer very well for the plane surface of the lens, and the glass will be ground down as shown in Fig. 8. If the lens is to be double convex, the finished spherical surface should be cemented to the end of the stick, and the opposite side proceeded with as before described. There are two methods of finishing the edges of plano-convex lenses: first, by holding the plane surface in a concave tool charged with emery and water until the edge is beveled to the required degree; and second, by chucking the lens on the end of a spindle projecting from the lathe mandrel, and centering it while the pitch or cement which holds it is still warm. Then a piece of brass, which is concaved to conform nearly to the periphery of the lens, and charged with emery and water. This tool is held against the edge of the lens after the manner of turning. The lens will soon assume a perfectly circular shape, and may be readily reduced to any desired size.

In making concave lenses the convex tools will be used, and the final finish will be given by a piece of silk cemented to the tool with pitch and charged with rouge and water.

For grinding larger lenses of longer focus an attachment like that shown in Fig. 10 will be required. It consists of a wooden box supported by a curved arm inserted in the tool rest support. A vertical journal box passes through the bottom of the box, and contains a shaft having upon its upper end a socket for receiving the grinding tool, and on the lower end a grooved wheel surrounded by a rubber friction band, which is revolved by contact with the face plate of the lathe. The speed of the wheel relatively to that of the lathe may be varied by raising or lowering the shaft by raising or lowering the box support in the tool port.

The glass to be ground is cemented to the face of a flanged casting as shown in Fig. 9, and is held down to the grinding tool by the lever attached to the box.



TOOLS FOR GRINDING SMALL LENSES.

The tool for large work may be made of cast iron. The center of the lens should be eccentric to the center of the grinding tool, so that the lens will be revolved on the face of the tool. The point projecting from the lever enters a small cavity in the center of the casting, to which the lens is attached, and insures an equal distribution of pressure over the entire surface of the lens.

Grinding and finishing a large lens is substantially the same as in the case of the smaller ones, the only difference being in the method of giving the final polish. In the case of a large lens, after the fine grinding, the tool is heated, covered with a thin coating of pitch, and a piece of thin broadcloth is pressed down

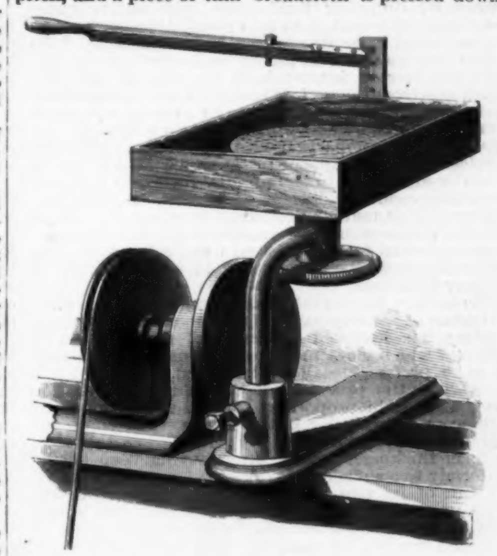


Fig. 10.—LENS GRINDING ATTACHMENT FOR FOOT LATHES.

on the pitch. This broadcloth surface is charged with fine rouge and water, and the lens is pressed down on it with considerable force as the tool is revolved. The cloth should be worked rather dry, and so much so at the end of the process as to offer considerable resistance to the rotation of the tool. M.

TEMPERED GLASS.*

By FREDERICK SIEMENS.

THE invention by M. De la Bastie of, so-called, toughened glass, which caused a great sensation at one time, induced the author of this paper to give close attention to the subject, which he proposes to bring before the Society on the present occasion. Being a glass manufacturer, there was every reason why he should interest himself in an invention which, entering the lists with great pretensions, claimed not only to revolutionize the glass trade as it then existed, but to supply a new material which should take the place both of glass and metals.

The author soon discovered that the De la Bastie process could lay no claim to the advantages to which it pretended, being indeed not a real manufacturing process at all, but rather a somewhat impracticable addition to known methods of glass making. The wholly finished articles to be toughened had generally to be annealed in the first instance by one or other of the usual means, and thereafter to be heated to such

* A paper lately read before the Society of Arts, London.

a degree as to render them soft; they were then immersed in a bath of heated oil, or other fluid, capable of being maintained at a temperature of from 350° to 400° Centigrade without evaporation.

The toughening of finished articles of glass in this way is not only a very costly addition to the original process of manufacture, but the articles themselves are very liable to have their shapes spoilt and their surfaces injured. But besides these objections, there is another important point to be considered, which is, the liability of toughened glass to burst suddenly into small fragments, either spontaneously or by a sudden shock, like the well-known Prince Rupert's drops, formed by dropping fluid glass into water, whose peculiarity of breaking up into powder has been generally supposed to be due to the sudden cooling of the soft or fluid glass. This theory is, however, only conditionally correct, inasmuch as the cooling influence, which acts from the surface inward, is not in proportion to the bulk of the glass, but to its surface, and must always act more quickly on those parts where the surface is large in comparison with the volume. Even the simplest form—a sheet, for instance—cools more quickly at the edges than in the middle, owing to the large surface for cooling which the edges offer. If, however, the cooling is regulated so that at every instant of time the temperature of the article is uniform throughout, no internal tension or strain can arise, and there will consequently be no tendency to crack or break in the way described.

The author, having satisfied himself by a series of experiments of the true cause of the spontaneous fracture of glass, has invented processes of manufacture by means of which glass may be thoroughly toughened, or, as he prefers to call it, hardened. The principle upon which the processes depend consists in cooling the glass, not in proportion to its surface, but to its volume or capacity for heat. The method employed will be readily understood by considering a sheet of uniform thickness, which, after having been heated uniformly to a sufficient degree, must be cooled on the surfaces of its two parallel sides only, leaving the edges uncooled. This is done by placing the heated sheet of glass between two cold slabs of suitable material, prepared in a peuliar manner. Uniform cooling of the whole sheet is thus secured, no matter what its shape, because the edges are not subject to the cooling influence caused by the surfaces between which the glass is placed. The plan adopted for various articles varies with their shapes; but it is on the principle of uniform heating and cooling that the author's processes of manufacturing hard glass are based.

Of these, the two principal are known as press-hardening and casting; but, besides these, there is a third, theoretically less perfect than the others, viz., semi-hardening or hard-tempering; this, though less important, may be advantageously employed, where presses would be unsuitable, and casting impossible or difficult, as in the case of bottles, lamp chimneys, etc.

Press-hardened glass has now been made, with constantly increasing success, for six years at the author's Dresden glass works. The output has steadily increased more than 50 per cent. annually from £600 value in the first year, until last year it amounted to over £7,000, or more than ten times as much. As there is no indication of a diminution in the rate of increase, the author anticipates that the manufacture will assume large proportions. The articles are mainly of plate and sheet glass, either flat or bent into a variety of shapes. Besides plain work, decorated sheets, such as sign-boards with enameled inscriptions, figures, and other ornaments, form an important part of the goods produced; the process, as already stated, is, therefore, one of manufacture (the goods receiving through it their definite shape and decoration), and not simply one of hardening or toughening. The glass is so hard that the diamond will not touch it, and it cannot, therefore, be cut or bent after manufacture; it may, however, be polished, etched, and slightly ground; its strength is at least eight times that of ordinary glass. As only absolutely homogeneous glass of the best quality is suitable for hardening, care must be taken in choosing sheet or plate glass for this purpose, so that it may not be in any way faulty, or contain stones, bubbles, or other imperfections.

The process of manufacture is as follows: The glass is first cut in the ordinary way to the requisite shape and dimensions, and is then exposed to the radiant heat of a peculiarly constructed furnace until quite soft; as soon as it has attained the necessary temperature, it is placed between cold metal plates, to be cooled down with a rapidity which varies with the thickness of the glass, but is in any case very great. The heating and cooling of sheet glass of ordinary thickness last altogether a minute and a half, a minute being the length of the heating and half a minute that of the cooling operation.

It is a remarkable circumstance that glass may be thus heated and cooled in so short a space of time without either cracking or breaking; this is altogether due, in the case of the operation of heating, to the uniform temperature of the furnace and to the heat being produced entirely by radiation; should these conditions not be fulfilled, the glass would break to a certainty. As regards the success of the cooling operation, this depends upon the uniform temperature of the glass before it is cooled, and upon that of the metal plates between which it is placed while being cooled. This uniformity of temperature, and the total absence of draught, which would cause irregular cooling, are the conditions under which the whole operation can be carried on with assured success.

It is most essential, as regards the good quality of the hardened glass, that the operations of both heating and cooling should be rapidly performed; it is also of paramount importance that the glass should be heated up to as high a degree as is compatible with its being removed from the furnace and placed between the presses, and one of the main difficulties in connection with the process was the arrangement of a proper mode of handling the heated glass, considering that it is almost in the molten state, and as pliable as a piece of cloth. The temperature to which the glass has to be heated is, therefore, far in excess of that of an ordinary annealing kiln, and it is owing to the high temperature employed that the glass can be bent and shaped, as also decorated and enameled, during the process of hardening. In the ordinary process of enameling, the glass can be exposed to a comparatively low temperature only, on account of its tendency to get out of shape. Retorts or muffles are generally used, and the temperature not exceeding that of an annealing kiln, the process of heating up is exceedingly slow, and the enamel to be fixed on the glass has to be of a very soft, easily fusible character; borax enamels are generally used, and even they cannot be properly melted so as to be thoroughly incorporated in the glass. The case is entirely different when glass is enameled by the hardening process; the temperature employed being so much higher, and the heat acting so much more quickly, a more refractory enamel, such as that used for porcelain, becomes available. While in the first case the enamel can be scratched off the glass, and does not resist acids, or even the action of the atmosphere, the enamel on hardened glass is as indestructible as the glass itself. From this it will be evident that the hardening is at the same time the most perfect enameling process, and by far the cheapest, no extra heating operation being required.

It will now be readily understood that press-hardening is essentially a manufacturing process, the same operation which hardens the glass regulating the shape of the article, and fixing upon its surface a highly refractory and consequently superior enamel, admitting of variations of color and design practically unlimited.

It would lead the author too far were he to attempt to enter into all the details of the manufacture of press-hardened glass, which are very numerous indeed, on account of the variety of articles made; these are still on the increase, and there is no saying how long this may continue to be the case.

The surface of the metal plates, or moulds used for the presses, may be so prepared as to produce more or less cooling effect on the glass as required. If the glass is to be hardened to a very high degree, the metallic surfaces must be of very high heat-conducting power, such as copper, and must be left quite bare; the glass must also be raised to a very high temperature, as it would otherwise crack during cooling. If it is proposed to harden the glass to a lower degree, surfaces of iron are used, this metal not being so good a conductor of heat as copper, while the temperature of the glass is also kept lower. By covering the surfaces of the iron presses with wire gauze, their cooling effect may be reduced to any required extent, so that a certain amount of hardening may be produced without rendering it necessary to heat the glass to such a temperature as to make it difficult to handle, or to cause it to stick to the furnace bed. If a still lower degree of hardening is proposed, the faces of the presses may be covered with asbestos paper, or even clay slabs may be employed.

It is very essential to the success of the hardening operation, that the heating should be done quickly and by radiation only, otherwise the surface of the goods and their general appearance will be impaired. The bed of the heating furnace must be made very smooth, either by the use of clay or of sandstone tiles, dusted over with talc powder, and should always be kept in perfectly good order; whenever it becomes uneven, or is otherwise damaged, new tiles are placed on the old bed.

Semi-hardened glass is made in the same large radiation furnaces as press-hardened, by means of the hard tempering process, of which the following is a description:

Finished articles, which are of a shape to which presses cannot be easily applied, such as bottles, are heated up to such a temperature as will permit of their retaining their form; each one is then placed in a casing of sheet iron, which is so arranged that the heated article shall not touch the inner sides of the casing. In order to effect this, the casing is provided with internal projecting ribs, which retain the glass article in position, touching it only at very few points. The casing with the heated article of glass within it is allowed to cool in the open air. Whenever it is a difficult matter to handle the heated glass, instead of placing it hot in the casing, the casing with the glass inside it is inserted in the heating furnace, for the requisite time, and then allowed to cool as before described.

The hard tempering process is only applicable to articles of nearly uniform thickness throughout; bottles with thick bottoms, for instance, are not fit to undergo the treatment, as they would be apt to crack both during heating and cooling. The strength of semi-hardened is about three times that of ordinary glass, and it is not affected to the same degree as the latter by change of temperature; the process finds much favor, as the constantly increasing orders sufficiently prove.

To secure success, a properly constructed heating furnace is of the utmost importance, as regards both processes. As already explained, it is necessary that there should be no draught within the furnace, that the heat should be uniform, and that the flame should not act directly upon the sheets or other articles of glass, which would be thus tarnished, and liable to break while being heated, or on cooling, if not heated uniformly. The furnace employed is the regenerative gas furnace, heated by radiation, which the author has lately introduced, with great advantage, for many industrial purposes, and fully described in a paper he read before the Iron and Steel Institute, in September last.

The third and last process to be described, which the author considers the most valuable of the three, is a peculiar mode of casting hard glass. This has not yet been introduced on a manufacturing scale, but the experimental castings produced have turned out to be quite satisfactory in every way. They consist of floor plates, grindstones, pulleys, tramway sleepers, and various ornamental work. The author thinks that castings might be produced, with advantage, for many other purposes, especially in connection with the building trades, but this can only be ascertained after works are established, which are now in course of construction, for the regular supply of goods manufactured by this process, as is already the case with the previously described processes. Glass may be cast in this way into a variety of forms which it would be impossible to produce with ordinary glass, owing to the liability of the latter to crack while cooling; it has, moreover, at least four times the strength of common glass, and can be made much more cheaply.

It is manufactured in the following manner:

Glass, melted in a tank furnace, such as described at the meeting of the Iron and Steel Institute already referred to, is tapped into moulds, as with iron castings. The process thus far resembles that carried on in an iron foundry, but differs from it, inasmuch as a special material is used in place of sand, and that the mould and the glass inside it are heated and cooled together.

The material or mixture to be used in place of sand must be selected so as to have, as nearly as possible, the same conductivity and capacity for heat as glass; in such a case, the glass and mould forming, as it were, one homogeneous body, the glass will cool without cracking, even if the cooling process is comparatively quick, which is quite necessary if hard glass is to be produced. Glass cast in this way may have almost any variety of form and inequality of thickness; in the last respect this process differing entirely from those previously described, in which only glass of uniform thickness can be dealt with. If care be taken that the surface of the glass does not approach the outer casing of the mould, it does not much matter how the cooling is effected. The great point is that the mould and glass should be brought to a uniformly high temperature, which should be rather above that at which press-hardened glass is made. When fully heated, the mould is taken from the furnace and allowed to cool in the open air, which generally acts quickly enough to produce a good hardening effect upon the glass within. When cold, the mould is opened, and the glass removed.

It will be readily understood, from the descriptions given, that the three processes differ so materially from one another that hardly any resemblance remains to show that they are merely different ways of treating differently shaped articles, in carrying out the principle of keeping the whole body of the glass at a uniform temperature during the operations of heating and cooling.

The De la Bastie process, as well as the ordinary tempering processes employed, fail in not being founded on the principle set forth; glass toughened by the De la Bastie process being cooled in a fluid bath, and ordinary glass in kilns, the cooling action is most active on the portions offering the largest surfaces to the cooling influence, and hence in the one case there is a strong tension or strain in the molecules, which causes them to break up spontaneously; and in the other case, to counteract that tendency, it is necessary that the glass should be cooled very slowly.

In all cooling operations the principle developed in the paper ought to be the ideal aimed at, and the author is convinced that ultimately every kind of glass will be more or less hardened in the cooling process; there is no reason why this should be done quickly, it may be done slowly, so as to allow of the glass being cut and ground while still possessing increased resisting power, and having less tendency to break under the influence of change of temperature. In the future, hardened glass will bear the same relation to ordinary glass that steel now bears to iron. It will, of course, be a long time before this result is brought about, just as it has taken a long time to develop the use of steel to such an extent as almost to have replaced iron in the market.

As a proof of the extent to which the production of hardened articles of glass has been already developed, the author has placed some samples of hardened glass on the table. The members of the Society of Arts will thus be in a position to judge for themselves as to the comparative value of this glass, as well of its strength and immunity from temperature influences. In the collection is included samples of military water bottles, of which more than 10,000 have already been supplied, mostly to volunteer regiments in this country, and glass similar to that used for fitting up the chart room on board H.M.S. Inflexible, which was ordered after a report of trials made on board of H.M.S. Glatton, where the tempered glass withstood the concussion of the firing of heavy guns.

From the steady progress in the past, there is every reason to believe that in future the hardening processes described in this paper will be applied to all manufactures of glass of an important character.

Several experiments were made at the conclusion of the paper, to show the strength of the tempered glass; pieces of ordinary sheet glass and of the tempered glass being placed on four corks, and a cricket ball dropped upon them from various heights. The ordinary glass broke with a fall of about two feet; while, in some cases, the tempered glass did not break except with a blow from a height of 5 feet 4 inches.

DISCUSSION.

Mr. E. A. Cowper said great thanks were due to Mr. Siemens for bringing forward this new manufacture in a practical form, but it was not a new thing, nor a small matter, seeing that the business had risen to £7,000 a year in six years. Several of the drinking bottles he had seen for some years past, and they were very much liked because they were clean; tea could be put in them one day and beer another. The question of cutting with a diamond was a very curious one. You could scratch the surface of some of these sheets, but you could not cut it; it would not split through as common glass did. Probably that was due to common glass being in a state of tension, which, when relieved by a scratch, caused the glass to fly right through; so that even plate glass, half an inch thick, would succumb to the slightest scratch of a diamond one hundredth of an inch deep. With this glass you could not do that. The castings would be an important new manufacture. The tempering was not so thoroughly carried out in this case as in the hardening of glass in other forms, but it was sufficiently hard to serve as sleepers for tramways and railway chairs for electric railways. He thought also architects would welcome this as a means of obtaining articles of various tints, whereas they at present had to search for different stones. By this process they could obtain them, to any extent, in various tints, and in any form, by casting. Something of the same sort was attempted some years ago by Mr. Attwood, who used basalt, which was cast at Chance's factory in Birmingham. He made some heavy castings for mantel pieces and so on, but it was a complete failure, as there was no means of hardening or probably annealing them. Some flew to pieces. One of the defects of the De la Bastie process was that the articles sometimes suddenly burst into little bits, the reason of which no doubt was that, being dipped into a liquid, one part necessarily got cool before another. If you wished to set up various strains by producing various temperatures at the same instant of time, there you had the process in perfection, for it was

impossible to dip a glass article even into oil at a high temperature without chilling it in such a way as to produce varying strains. The cooling surfaces Mr. Siemens used were, first, a large plate of iron on which the glass was quickly laid, and then the top plate came suddenly down upon it, and it was squeezed perfectly flat, so that every part was in contact with the iron. If it was merely laid on a sheet of iron, the glass might cockle a little, and the proper effect would not be produced. Various experiments would be necessary to give the exact comparative strength, and he should have liked particularly to see experiments on the actual tension by pieces being put into a hydraulic press and pulled apart. It was evident this product was very much liked in Germany, and some day, no doubt, it would be equally popular in England.

Mr. P. F. Nursey said about ten years ago toughened glass by the De la Bastie process was brought under his special notice. He was requested by some friends to investigate and report upon it, and for that purpose he went to the factory near Paris and saw the process, which was heating the glass and plunging it immediately into hot oil. It was singular that long before De la Bastie worked out that process, he attempted the very means which Mr. Siemens had adopted, but without success, for he attempted pressure, adopting the idea from Sir Joseph Whitworth's process. He had had the honor of reading a paper in that room on the subject, and perhaps some were present who witnessed the experiments on that occasion. To his mind, those shown that evening did not compare with those which he then showed. He might say that, when he visited M. De la Bastie's factory, he tried an experiment with a number of champagne tumblers which were placed edgeways on a shelf. He fired at them with a saloon rifle at twelve paces; several times he knocked them off their perch, and one obstinate one he knocked off twelve times in succession, and only broke it at the thirteenth shot. It was a very severe test. In order to ascertain what the real strength of the material was, he carried out a series of tests in conjunction with Mr. Kirkcaldy, and their report was made on the 18th May, 1875. There were ten pieces of tempered and ten of untempered glass of various lengths, 12 to 15 inches, and 4 inches broad, and all the same thickness, about 0·265 inch. They were placed on supports giving a bearing of 5 inches, a block of wrought iron being cut out to make a pan beneath. Under each edge were laid strips of India-rubber, and on the top was placed another piece of rubber, and on that pressure was brought from a knife edge, in some instances by a gradually increasing weight; in others the strips were placed in a testing machine, and the knife edge brought on them horizontally. The mean result was that the ordinary glass stood 206·2 pounds; the tempered glass, 828·1. Mr. Cowper had referred to the desirability of having tensile tests made, and he hoped he would carry that wish out, but he believed it would puzzle his ingenuity, as it did his own and Mr. Kirkcaldy's, for they could not get the glass to be held by any known means; they could not get a bite on the glass. With regard to the tests made by Mr. Wallace, he did not think the material could have been properly tempered. In some instances, glass articles made by English manufacturers did not come out so well as those made by De la Bastie himself. Having quoted from the report in the Society's *Journal* the account of his own experiments, he added that on that occasion one gentleman dropped a plate of the glass on an iron hearth at a distance of from 1 foot up to 5 feet without breaking it. He did not deny that Mr. Siemens had improved on this process as far as ornamentation went, but he did not think De la Bastie had attempted anything of that kind, though his glass could be ground by the sand-glass process. He had some tumblers at home, beautifully engraved with his monogram, which had been in use for ten years. The process had now dropped into abeyance, but recently he understood it was being brought out by another company.

Mr. Frederick Siemens said his process and that of De la Bastie could scarcely be compared, because the latter was merely a toughening process, while his was one of manufacture, by means of which he shaped and hardened the glass in a single operation, either by means of presses or casting into moulds, and in a new manner. The De la Bastie process was only an additional operation, applied after the article was finished, to toughen it; but even for that purpose it was wrong, inasmuch as the cooling influence acted in proportion to the surface, whereas it ought to act in proportion to the bulk of the glass. Those parts which exposed much surface to the cooling influence cooled more quickly than those of less surface, and, consequently, there would be unequal cooling, which should be avoided. At each unit of time the whole article should be at one temperature, and that could only be effected by regulating its temperature according to its capacity for heat. If one part was cooled more quickly than another, there was a strain which could never be removed. For that reason, the process of cooling in a bath was wrong; while the slow cooling applied to ornamental glass was expensive. By the ordinary mode, many articles which he had shown could not be produced at all, even if cooled ever so slowly, for they would have very little strength, and the least accident would cause them to break. Toughened glass was apt to break spontaneously; owing to the tension set up during the process of toughening; generally speaking, if it did not break very soon, it would last a long time, but its liability to break was the reason it was expensive. He had omitted many points of detail from the paper for the sake of brevity, but he described three different processes, in each of which there were many peculiarities. He had already described the construction of the furnace at the Iron and Steel Institute, and a great deal depended upon it, not only as regarded the success, but also the economy, of the operation. [Mr. Siemens drew a rough sketch on the board to show the kind of furnace he used, in which the flame was shown to pass over the top of the furnace without touching the articles, radiating the heat down upon them.] On the bed of the furnace were tiles on which the articles were placed. The flame was about three feet from the glass, which caused a uniform heat, and prevented injury to the articles themselves and to the bed of the furnace. The articles were removed with wooden shovels, impregnated with water glass so as to render them incombustible, and they were then placed upon a cool metal plate, upon which another was pressed down. He had only brought forward manufactured articles such as were sent out to be used; the bottles would stand four times the ordinary wear and tear, and the sheets eight to ten times. He arrived at this conclusion from the circumstance that the breakages of the street lamps of Dresden and Berlin were now only about one-tenth what they used to be, and only cost one-tenth for repairs. He could have prepared glass which would stand very much more strain than that tested; he might have selected pieces which had stood the test already; but those shown had been taken quite at random. Sometimes a piece would break at five feet, though it had already stood the test at ten feet, or it might be dropped on the ground several times without injury, and eventually break, the difference of result depending entirely upon how the glass was struck. Bottles and hollow articles were the most difficult to harden; the sheets and hard castings were the most perfect, but hollow articles could not be made very well in the way in which those were made. Pipes might be cast, moulding them somewhat as iron pipes were, but it would require a little ingenuity. The strength of an article could be increased by heating it to a higher temperature, and cooling it more rapidly, but there was a certain limit when the manufacture became unsafe; and for commercial purposes, it was necessary to avoid losses through breakages, which would make the articles expensive. With regard to the price, it differed very much; some articles were very cheap indeed; it did not cost more to glaze a street lamp with tempered than with ordinary glass, but then the glass was supplied in sheets ready cut to the exact size, and the expense of the glazier's time in cutting the glass, and the loss thereby occasioned, was saved; but it could only be introduced for that purpose as corporations of towns came to have lamps or window panes of a uniform size. Decorative glass was produced more cheaply by this process, because the ordinary mode of decorating was by an additional process which was very expensive; the glass having to be heated in a muffle, slowly, besides which the heat used to burn in the designs and inscriptions was not high enough to fix them well. There was hardly any limit to the designs which could be produced in this way; anything that could be done on porcelain could be done on this glass, and it could be done more cheaply. It would be useful for signboards of houses or shops, but there must be an establishment near the place where the glass is to be used, as it would not pay to send single sheets from Dresden to London. With regard to the hard castings, he had not had so much experience, because they had not yet regular manufacturing establishments, and had hitherto only manufactured them experimentally, whereas real knowledge on such subjects was only to be attained by practical working. The hard-casting process, although it had not yet been brought out commercially, was, in his opinion, of the utmost importance, as it was an entirely new process, by means of which glass might be made in any shape which could be moulded, and of a strength which could not otherwise be produced. The material employed for moulding was certainly dearer than the moulding sand used for castings of iron. This was due to the circumstance that it must not only be suitable for moulding, but had to be, when moulded, of the same conductivity and specific heat as glass. He was still making experiments, so as to obtain the most suitable material for this purpose, but had found various mixtures of powdered porcelain and glass pots, metal turnings, and filings, and such minerals as heavy spar and magnetic iron ore, to be suitable when mixed in certain proportions. On the whole, these materials were not dear, and, as regarded the labor and expense of moulding, it would probably be about the same for castings of glass as of iron. As a manufacturer, he looked upon cost as a most important matter for consideration, as, however good a thing might be, it was of no value commercially unless cheap enough to find buyers. As regarded the hard-cast glass, he could produce a hundredweight of castings for about 5s. 6d., which should be cheap enough for any purpose for which it was proposed to be used. He was now erecting a factory which would be at work in a couple of months' time, and, later on, he should be pleased to give the Society further information on the subject. He felt quite satisfied that orders would come in, for his hard-glass castings supplied a want which was felt on all sides. Glass was not liable to oxidation, or to wear away, and as soon as it could be depended upon for strength, and could be made cheaply, it would be applied for purposes for which metals, stone, and porcelain had hitherto been used. If a factory were established in London, he believed a great trade would spring up.

PURIFICATION OF WATER FOR INDUSTRIAL PURPOSES.

As well known, natural water is not always of good quality. It often contains large proportions of bicarbonate of lime, or sulphate of the same, which render it unfit for domestic purposes and for feeding steam generators in the industries. Such water can be purified by means of reagents that precipitate the saline matter. For example, the addition of lime water in proper proportions will, under the influence of an excess of carbonic acid, convert the calcareous matter that the water contains into insoluble carbonate. The nature and proportions of the reagents to be used must be determined by a chemist from a qualitative analysis of the water. Aside from this purely chemical question, there is the question of the apparatus needed for the purification, and this is the one that we shall now examine in making known the system of Messrs. Gaillet and Huet. The annexed engraving represents the apparatus of these engineers. At the upper part there are three reservoirs that serve for the preparation of the reagents. Beneath, there is seen a large rectangular receptacle in which the water, in contact with the reagents, is purified, and deposits a precipitate, in a series of compartments having sides that slant at an angle of 45°.

APPARATUS FOR PURIFYING WATER.

The following principles have served as a basis for this arrangement: When lime in excess is shaken up with water, the latter becomes quickly saturated with the former in the proportion of about nine grains to the pint. The decantation of water holding an excess of lime in suspension is very easily and quickly effected. When a liquid is made to flow from a vessel through two orifices of given section, the flow through each of them remains proportional to the height of the liquid. The discharges will remain in constant ratio, whatever be the height of the liquid in the vessel. To sum up the operation, we may say that, for the purification of water, it suffices to lead it in definite proportions into the purifying and clarifying apparatus, where it mixes with an equally definite quantity of the reagent.

Chemical purification, which renders the injurious matters insoluble, results from the simple mixture of the water with the reagent, and requires, according to the nature of the salts to be precipitated, a greater or less length of time, and this serves as a basis for determining the capacity of the apparatus designed for the operation.

It has been Messrs. Gaillet and Huet's object to construct a decanting apparatus that should realize the most favorable conditions for facilitating a deposit of the precipitate and separation of the liquid. They have very happily solved the question as follows: In the apparatus, the liquid has successively and alternately, and without abrupt changes, an upward and downward motion. Moreover, it circulates in thin strata, although the reservoir is of such a form that the space occupied by the liquid is quite limited. In principle, the apparatus is a rectangular reservoir containing a series of diaphragms having a slope of 45° and riveted alternately to two opposites sides of it. So the system as a whole consists of a series of alternate, sloping compartments that converge toward the same surface of the apparatus, and each of which is provided with a cock.

The liquid, charged with solid particles, reaches the bottom of the apparatus, begins to ascend, and, so to speak, slides over the first diaphragm. After this it passes into the following compartment, and descends upon the second diaphragm in order to ascend upon the third, and so on. During this alternating motion, the solid particles, submitted to the action of gravity, on the one hand, and held back by the diaphragms, on the other, rapidly deposit. By an inspection of the figure it will be seen that these particles, upon sliding over the sloping diaphragms, will collect at the lower and angular part of the compartments, from whence they may be easily removed by opening the cocks.

The numerous applications that have been made of this apparatus for the chemical purification and clarification of water have proved that decantation is effected very rapidly and perfectly therein. Owing to the inclination of 45°, the deposit descends uniformly to the bottom of each compartment, and thus escapes being carried along by the current. In fact, collecting in that portion of the liquid which is situated outside of the current, it cannot possibly be carried along with the latter.—*La Nature.*

RAPID SMELTING PLANT.

SINCE the successful introduction of Mr. Stewart's "Rapid" cupola for smelting iron about two years ago, by Messrs. Thwaites Brothers, of Vulcan Ironworks, Bradford, Yorkshire, the inventor has directed his attention to the problem of smelting ores in cupolas with refractory linings. Down to the present time the result has not been entirely satisfactory, owing to the difficulties—both mechanical and chemical—which presented themselves. The slag in the ores, having so great an affinity for the silica, etc., in the bricks, corroded the lining to such an extent that it was quickly destroyed, and its constant replacement could not be tolerated in a smelting establishment, where, from the very nature of the operations, it is a *sine qua non* that they must be continuous. To meet these conditions, the water-jacket system has been resorted to, but with, important improvements. The water-jacket cupolas are in extensive use in California, South America, and Australia. The system is illustrated in the engravings of our present issue, where Fig. 1 shows very clearly the arrangement of a copper smelting plant. The "Rapid" smelter shown is a No. 8 size, 5 feet diameter outside the shell, an enlarged exterior view of this smelter being shown in Fig. 2. There are eight tuyeres of 5 inches diameter in one row. The tuyeres are surrounded with an air-belt. The water-jacket extends from the tuyeres up to the charging door. The water enters at the top of the jacket on the right hand side, and after circulating all around the belt is taken away at the bottom. Mud-holes are provided to clear out the sediment which is deposited from the water. The smelted ore is tapped into portable receivers to be run to the ingot beds or to be subjected to further refinement. The blowing is effected by means of a No. 5 Roots blower with a vertical engine, as seen in Fig. 1, this being the size most generally used in Australia and Spain.

It is but a few years since that the only process known for the reduction of copper ores was the reverberatory furnace, but the introduction of the "Rapid" copper smelter will make practicable the reduction of copper ores by a process which is simple in operation and economical in results. This has been demonstrated in the far West, and there is scarcely a copper mine located favorably as regards fuel and transportation that cannot be worked profitably. We may observe that a No. 15 "Rapid" cupola will smelt refractory ores of the following composition: 43 per cent. pyrites of iron, 27 per cent. galena, 20 per cent. silica, 10 per cent. zinc blende. This after being roasted and slagged is mixed with 11 per cent. limestone. The cupola smelts from 30 to 35 tons per twenty-four hours, with about 15 per cent. of fuel (charcoal) of poor quality. The water jacket requires about 450 gallons per hour, and the pressure of blast 15 inches water-column, supplied with air from a No. 5 Roots blower running under half speed, 150 revolutions per minute, and forcing 3,000 cubic feet of air per minute. The water tank is supplied, on the top dressing floor, with a small donkey pump. A crushing machine for reducing the ore is driven from the Roots blower engine.

A complete silver smelting plant, on Mr. Stewart's system, is illustrated in Fig. 3 of our engravings. It consists of two "Rapid" smelters, a Roots blower, engine and boiler, etc. Fig. 4 is a sectional elevation of the cupola. The water jacket cupolas are in extensive use in California, South America, and Australia. The "Rapid" process has also been recently introduced at Cobar, in New South Wales. Pyrites are smelted down in a cupola, the mixture of ores yielding a matte of 20 per cent. to 40 per cent. copper. This is tapped direct, as hot as possible, down a chute into the converter, and blown into rich matte or blister copper. It would

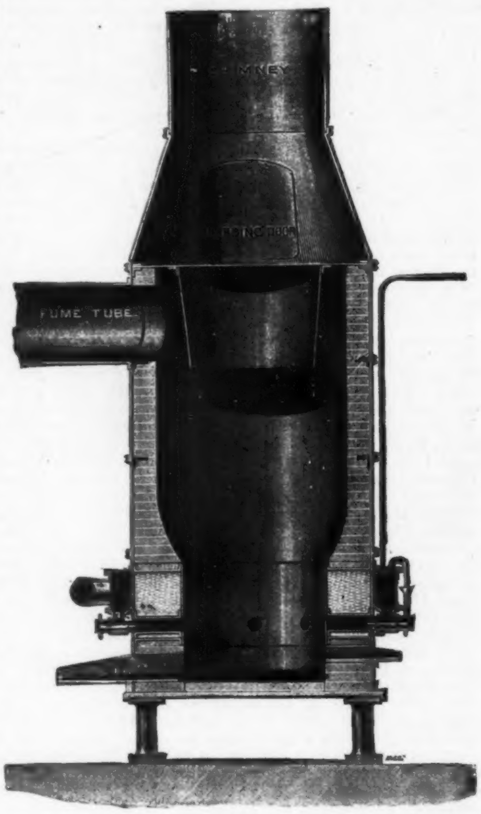


Fig. 4.

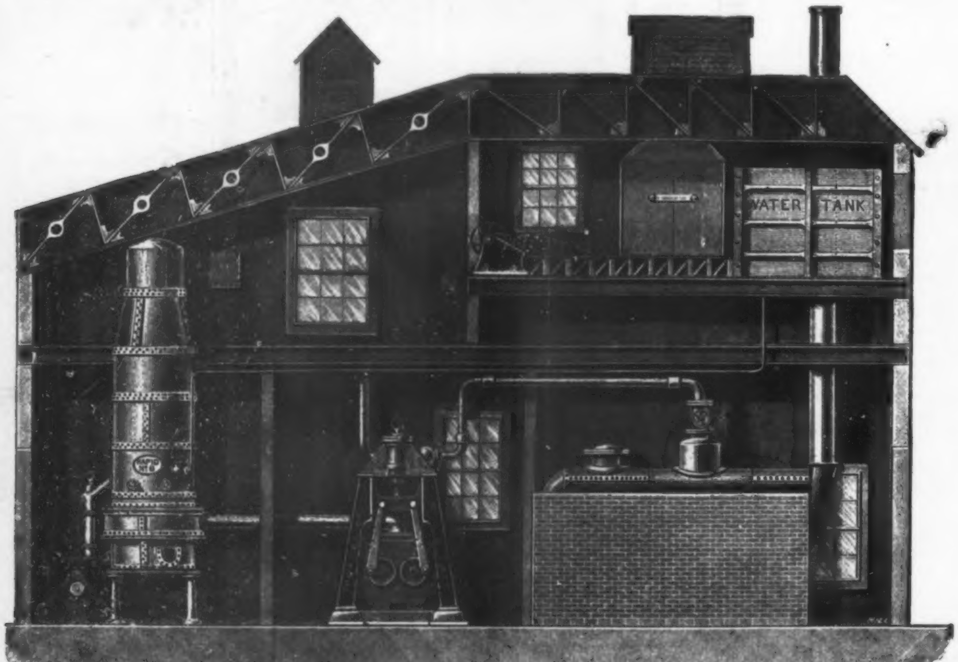


Fig. 1.

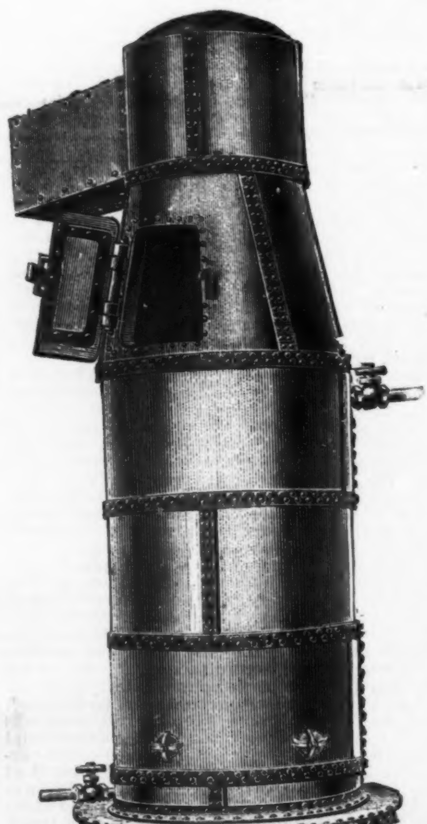


Fig. 2.

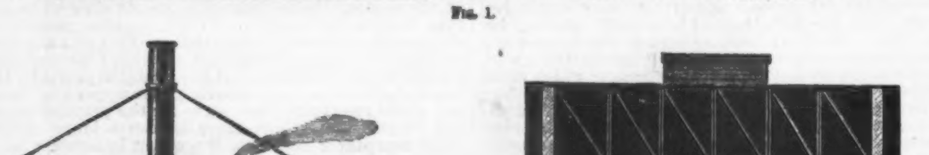


Fig. 3.

STEWART'S RAPID SMELTING PLANT.

seem that works on the "Rapid" principle are comparatively inexpensive, can be run without loss of time or expense for repairs, giving in all cases the best product obtainable at the smallest possible cost of fuel and attendance.—*Iron.*

SUGGESTIONS IN ART.—THESEUS CONQUERING THE CENTAUR.

Marble Group by A. CANOVA.

THE city of Vienna possesses three of the finest works of the celebrated sculptor Antonio Canova; they are the group "Amor and Psyche," in the palace of Prince Metternich; the moument of the Archduchess Maria Christina, in the church of St. Augustine; and the group "Theseus killing the Centaur," the latter being located in a small building which is an imitation of the Theseus Temple in Athens, and is located in the Volksgarten.

At the present day it is the general opinion that too much was made of Canova during his time, and it is true that after him other masters showed a greater and better understanding of antique sculpture than he did, but, nevertheless, he was the first to call attention to the beauties of the plastic works of the ancients, and to oppose the art styles of the Rococo period. The Venus de' Medici had a great influence on Canova as well as on many others after him. The coquettish beauty of this statue was the ideal of all Hellenic beauty of that generation which had not yet seen the Venus de Milo, and was their model for all forms that were to have rare and exceptional beauty. Canova attempted to surpass this model in elegance, delicacy, and tenderness in his group "Amor and Psyche."

The figures in the group on the monument of the Princess Maria Christina, the favorite daughter of the Empress Maria Theresa, are much more noble, but are by no means Christian figures, and do not possess the same dignity that distinguishes the figures on the monument of Pope Clement XIII. These monuments come between the extremes of the tender and affected young gods and goddesses and the enormously powerful and rather uncouth gods and heroes; but in his group "Theseus conquering the Centaur," Canova has been most successful in representing the powerful within the bounds of beauty.

The battle is ended, the monster's power is broken, and he is no longer capable of resistance, but makes a final attempt to remove the hero's left hand from his throat. Theseus braces his left knee against the breast of the monster, and holds his club raised in his right hand ready to crush the skull of his adversary. It almost seems as though he hesitated to kill his antagonist, but the expression of his face removes all doubt. It has been claimed that the muscles are represented too powerful, but this certainly is not the case, as they only show the forms that the activity would give them. The relaxing of the centaur's muscles is shown specially well.

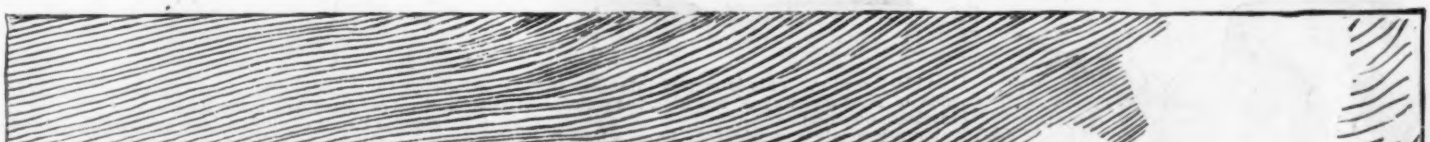
Canova selected all his subjects from Hellenic myths. The uncouth centaurs were invited to the wedding of King Pirithous with Hippodamia, and they made the attempt to steal the bride and other women. Theseus, who was the friend of the king, as usual performed wonders of bravery and courage. He attacked the centaur king, Eurythos, and slew him, the last moment of which battle is represented in the group. The group is 18 ft. high and 12 ft. wide. The model was finished in 1805, and was to have been placed on a triumphal arch in Milan. In 1819 the Emperor Francis saw the group in the artist's studio at Rome, and bought it. The transportation of this enormous piece of marble statuary from the Tiber to the Danube was a work of great difficulty in those days. In the Volksgarten in Vienna, an exact copy of the Theseus Temple in Athens, built 476 B. C., was erected on a small scale, and was completed before the statue reached Vienna.—*Illustrirte Zeitung.*

SUGGESTIONS IN ART.—THESEUS CONQUERING THE CENTAUR.

LIQUEFACTION AND SOLIDIFICATION OF FORMENE AND OF NITRIC OXIDE.

By K. OLZEWSKI.

THE author, unable to procure absolutely pure formene, prepared it both by the ordinary method, which yields a product slightly contaminated with acetone and hydrogen (the latter of which is not readily removable), and by the method of Gladstone and Tribe,



SUGGESTIONS IN ARCHITECTURE.—*From The Architect.*

which yields a product containing the vapor of methyl iodide. For determining the congelation point he employed the gas prepared from sodium acetate. The critical point was observed at a pressure of 80 mm. of mercury and a temperature of —185·8 deg. At 5 mm. of mercury and a temperature of —201·5 deg. there was formed a white, snow-like mass. Nitric oxide was prepared by heating ferrous sulphate with dilute nitric acid. In the experiments it was very important to prevent the entrance of atmospheric air. The critical point was observed at 71·2 atmospheres and—93·5 deg. At a pressure of 138 mm. of mercury and a temperature of —167·0 deg. solidification ensued.

If the apparatus is kept free from air, the liquefied gas is colorless; but if air has been permitted to enter, it takes a greenish tint and holds in solution a trace of nitrous anhydride.

M. Cailletet remarked that he had first made known the procedures for the liquefaction of ethylene and formene and the use of these condensed gases for obtaining the liquefaction of oxygen. He had determined the critical point of ethylene and the tension of these gases at different temperatures, and had shown that formene slightly compressed and refrigerated in boiling ethylene at the atmospheric pressure is resolved into an extremely mobile liquid, which in returning to the gaseous state gives cold sufficient to liquefy oxygen. M. Cailletet has also shown that the figures published cannot be accepted without reserve, because none of the methods for preparing these gases yield a pure product, and a very small quantity of a foreign gas is sufficient to modify the critical point.

THE PHYSICS OF TENUITY.*

THE very apt comparison of Oliver Wendell Holmes, in which the bursting of a soap bubble is invoked to illustrate the destruction,

"All at once and nothing first,
Just as bubbles do when they burst,"

of the immortal "one horse shay," has been chosen as

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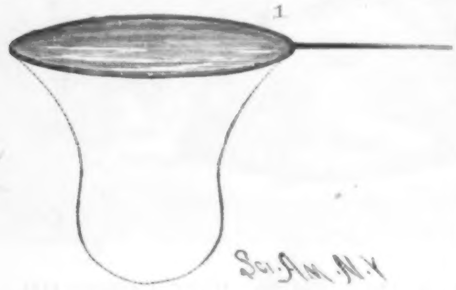

the text for our investigations of soap bubbles and films this evening. We find ourselves thus brought face to face with one of the lightest of all themes. For soap bubbles have been studied by one of the great investigators in the line of physical research as illustrating the laws of matter abstracted from gravity. I allude to the blind scientist, Professor J. R. Plateau, of Belgium.

The science of physics achieves some of its greatest triumphs in the way of exact measurements of small

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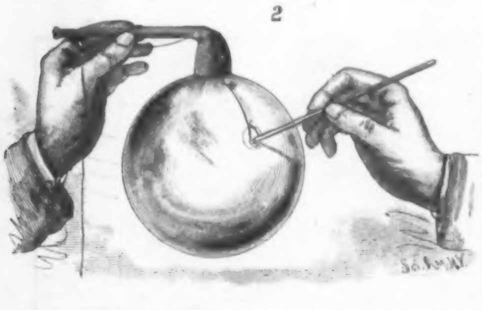

dimensions. It has gauged the thickness of gold leaf so thin that the dense metal, as you see, is actually transparent. Held in front of a candle flame, or, better yet, of a piece of burning magnesium, it permits the passage of green light. The leaf may be thinned still further by cyanide of potassium, when violet light will pass through it. We know that something like 300,000 of these leaves would be required to make a pile an inch in height. But we are going beyond this, and are to descend from a solid mass of $\frac{1}{300000}$ of an inch in thickness to a liquid film of far greater tenuity, yet of sufficient strength to support some weight.

3

It is told of Sir Isaac Newton that a servant had seen him several times engaged in blowing soap bubbles. He was doing this for a purpose, as he was then studying the colors of thin layers, the subject of the interference of light. To this cause are due the brilliant colors of the bubble. So childish an occupation seemed in the eyes of the servant unworthy a man of his appearance. She came to the conclusion, and stated it to her mistress, that a harmless insane man occupied the next house, who spent his time in blowing soap bubbles. Yet it was this investigation that added a leaf to the wreath of his renown, for he measured the thickness of the film, calculating it to be in places $\frac{1}{2500000}$

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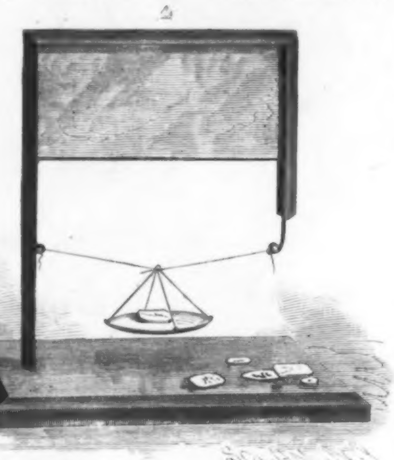

of an inch. I can only give a general idea of the way in which he did this. He had observed that when a convex lens was pressed down upon a flat plate of glass, rings of color were produced, while a black spot filled the center. Knowing the radius of curvature of the lens and the diameter of the rings, he easily ascertained that thickness of the layer of air where each color was produced. Observing similar colors and a tendency to the production of an area of blackness in the soap bubble, he drew the conclusion that the films of water in the bubble and of air between the glass plate and lens were of equal thicknesses for similar colors and for

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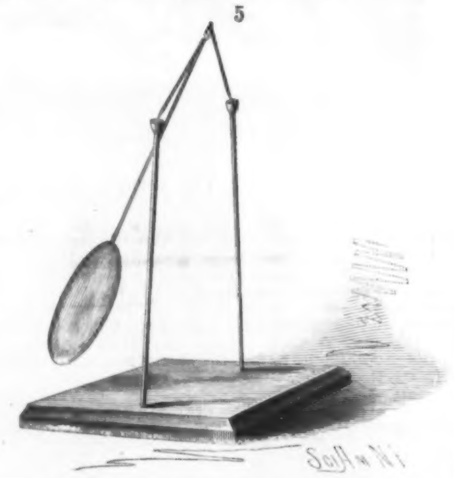

the black center. This is merely intended to give an idea of Newton's way of reaching the solution of this intricate question.

More recently investigators have adopted an electrical method of determining this minute dimension. Two wires are inserted in the film, and a current of electricity is passed from wire to wire through the film. From the resistance to the current the thickness of the film is calculated. It is thinnest in the black, only $\frac{1}{15000000}$ of an inch; then it suddenly increases to sixty-five times this thickness, and varies for the different colors; so that after all the soap bubble in most parts is a great deal thicker than gold leaf.

Sometimes an optical method is employed, which consists in passing a ray of light through a number of bubbles contained in a tube. The refractive properties

6

of the ray, before and after passing through a determined number of bubbles, give the basis for deducing the thickness.

The true conception of a soap film is that it consists of two films with the space between them filled with liquid. The thickness of the film proper may be inferred from the calibration of the black spot given above.

The thin film of gold is matter in the solid state. Films such as we propose to study this evening are composed of matter in the liquid state. The molecules are capable of almost frictionless motion, sliding about one over the other. We assume that all liquids are bounded by one of these extremely thin films, composed of the liquid itself. The film is in a state of con-

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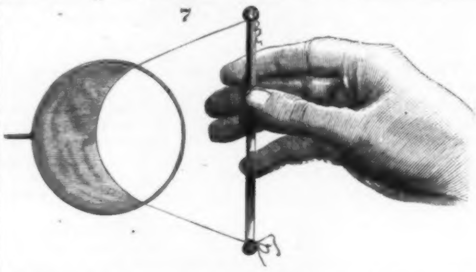

siderable tension, and strained like a membrane of rubber. To study the properties of this film, we remove it, so to speak, from the fluid mass that it normally would surround or cover. By dipping a ring into the solution, and withdrawing it, it comes out filled with a flat and beautiful film, Fig. 1; or dipping the mouth of a pipe bowl, which is for this purpose a ring, we find it closed in like manner with a film. Then, by blowing air through the stem of the pipe, we cause the film to bulge out, and form a hollow sphere or soap bubble. This

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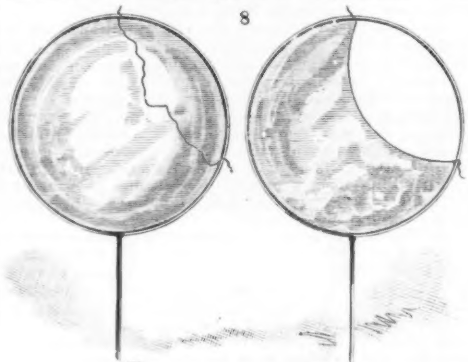

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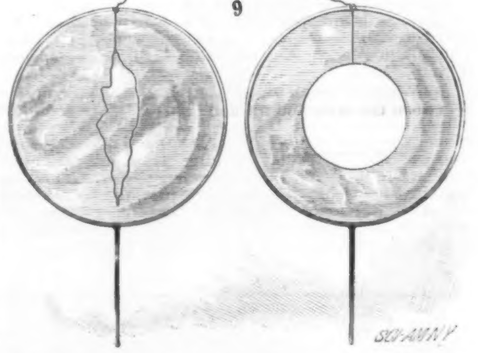

gives us a globular film of soap solution, devoid of its natural contents, the water itself.

Having blown our bubble, we remove the pipe from our lips, and see what happens next. The bubble grows smaller. On holding the open end of the pipe stem near our cheek or lips, we can feel the rush of air escaping. Pointing this same end against a candle, the flame is disturbed, and by using a pipe with a large apertured stem we can extinguish the flame, so strong is the blast produced. If I hold my finger over the end of the pipe stem so as to close the aperture, the

10

bubble does not diminish in size at all. By particular management I can make an opening or hole in the bubble. This I do by suspending from the bowl of the pipe a silk thread ending in a loop, well moistened with the solution. On blowing the bubble this thread adheres to it, and by touching the bubble within the loop with a hot wire or piece of blotting paper the film will break within the area inclosed by the thread

* Lecture on Soap Bubbles. Delivered before the New England Society of Orange, N. J., May 2, 1885. By T. O'Conor Sloane, A.M., E.M., Ph.D.

and the loop expand to its widest extent, thus forming a circular hole through the bubble film (Fig. 2).

I have made one about the diameter of a lead pencil, and the bubble collapses with great rapidity. Blowing another bubble, and making the same sized aperture in it, I can only keep the bubble of its full size by the most vigorous blowing. Holding a lighted candle in

11

front of the aperture, it is extinguished by the air rushing out of the bubble. The story told by all this is quite clear. The soap bubble film is in a state of high tension, just like the inflated balloon, and is perfectly elastic, having the power of expelling air from its interior with some force, as it contracts. Remembering how thin it is, we acquire a new idea of its tenacity and strength by analyzing the simple experiments that we have witnessed.

We can measure the pressure of the confined air very simply by immersing in water the end of a glass tube connected to a pipe stem, to whose bowl an inflated bubble is attached. The depression of the column within the immersed and transparent tube measures the pressure. It is a small fraction of an inch of water (Fig. 3).

We have seen in a general way how Newton determined the thickness of the film, and we have seen how easy it is to measure the internal pressure of a soap bubble. The tension or elasticity of the film is susceptible of measurement directly. A little frame, three-sided and rectangular, with grooved sides, is provided with a wire that slides freely up and down in the grooves, maintaining a horizontal position, and which has attached to it a little pan for weights. The wire is placed in the frame in contact with the upper side, and soap solution or other fluid as desired introduced between the wire and frame. This is most conveniently

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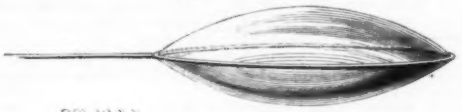

done by turning it all upside down, and then dipping the top into the solution, or a little is "painted" on with a small hair pencil. When restored to its normal position, the wire will remain attached to the top if of proper lightness. Then by adding weights the wire can be drawn downward, still hanging by the film as if by a thin membrane (Fig. 4), and drawing down the delicate curtain until the limit is reached and the film breaks. The weight of the wire, pan, and weights added shows the tension of the film, at any desired degree of extension. If this weight be doubled, the wire will descend twice as far, and so on, as long as the limit is not passed. The general law is that the tension per superficial unit is always the same, whether the film is large or small, straight or curved. This does not always hold good; a small bubble exerts more pressure on the confined air than a large one. Pure water has a very high modulus of tension; soap solution has only one-third as much. For two surfaces of pure water it is 167·16 milligrammes per square centimeter or 16·62 grains per square inch. For a soap bubble film it is 56·04 milligrammes for both surfaces per square centimeter, or 4·63 grains per square inch. Thus, if we have a frame two inches square filled with a film of soap solution, each side is drawn inward with a force of about 18 grains. From this it would seem that pure water should make the strongest bubbles. But the elements of strength in a bubble are permanency, and viscosity or tensity of film. High tension tells

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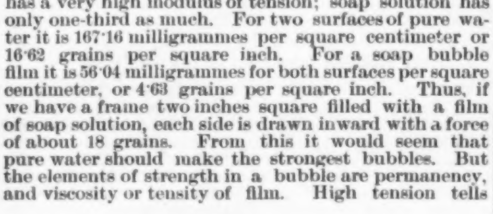


against them. The film of pure water runs away or thins itself to nothing with great rapidity. It has such high tension that, when a bubble is formed, the tension squeezes out the air and breaks the bubble like an overinflated balloon. By the decrease of tension and the increase of tenacity we can make it stronger, sacrificing tension to permanency. This may be done by adding soap and glycerine to it in just the proper proportions to combine the desired properties in the most advantageous ratios. Later on, the subject of mixtures for bubbles will be returned to.

If we immerse a ring of wire about two inches in diameter in soap bubble mixture and withdraw it, we shall find its opening filled, as already described, with a beautiful film reminding us of the wings of a dragon-fly. The

14

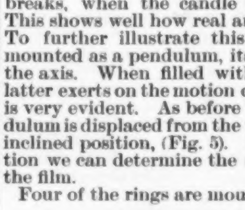
straightness and stiffness of the film suggest high tension. On blowing against it, it is forced out so as to form a purse-like shape of very characteristic outline, but which contracts immediately to its original disk-like form when the blowing ceases. (See dotted lines in Fig. 1.) This illustrates its elasticity and strength. As we shall see, many very elegant experiments can be performed with these flat films in rings or frames. One inch to two inches in diameter is a proper size, and they should be provided with a handle, made of an extension of the wire. The ends should meet where the circle is formed, so as to close it perfectly. This may be effected by twisting or, better yet, by soldering. If there is any opening in the ring where the ends come together, they will work very poorly or not at all. The wire should not be too thick nor too smooth. Hair-pins

15

answer quite well for extemporized rings in home experimenting.

I shall again fill one of these frames by immersion in the solution, and withdraw it filled with a film. On shielding with it a candle, I can blow quite hard without in the least affecting the flame, until the film breaks, when the candle is immediately blown out. This shows well how real and substantial a thing it is. To further illustrate this point, the ring may be mounted as a pendulum, its surface being in line with the axis. When filled with film, the retardation the latter exerts on the motion of the pendulum as it swings is very evident. As before blowing against it, the pendulum is displaced from the vertical, and sustained in an inclined position, (Fig. 5). From this angle of inclination we can determine the exact weight sustained by the film.

Four of the rings are mounted on wires that form the



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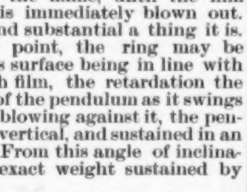

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radii of a circle, and are attached to an axis. The whole is supported on standards so as to be free to rotate. Now, on filling the rings with films, the little mill can be driven around several times by blowing against its vanes, until the perishable sails break one by one (Fig. 6). This is the direct action wind-mill, resembling in principle the paddle-wheel of a steamer. But on substituting inclined vanes, there would be little trouble in making a helical mill of the regular type. These experiments show how strong and real a membrane it is. Its elasticity is next to be considered. One of the rings is filled with a film, and a thread, well moistened with the solution, is laid loosely across it. It is attracted and held by the film, lying closely upon its surface. With a hot wire or a piece of blotting

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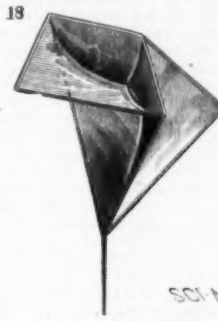

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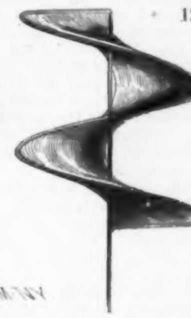

paper I break the film on one side, when the thread is snatched across the ring so rapidly and drawn so tightly against the side as to seem to disappear. The contraction of the highly elastic film has done this. Next, by pulling out the ends of the thread (Fig. 7), which are preferably attached to the extremities of a little bar or wire, the film is drawn out, little by little, until the loop once more is quite filled with it, and the thread may be pulled entirely away. The thread, during this operation, is strained and drawn by the tension into an arc of a circle. If released before the ring is filled, it immediately flies back to the other side of the ring as before.

If the thread, instead of lying unattached across the ring, be tied to it at each of its ends so as to leave some slack, on breaking the film on one side of it the thread is instantly drawn toward the other side, as far as it can go, forming the arc of a circle (Fig. 8). This form it takes in virtue of a geometrical principle that, of all surfaces of equal perimeter, that bounded by a circle is the largest.

We may place a closed loop of thread in the film, where it will lie in an irregular shape. But if we break the film within it, it flies open to its widest area, forming a perfect circle, following out the geometrical principle enunciated above (Fig. 9).

By the use of these rings we can perform several very pretty experiments with bubbles. I shall blow a bubble and suspend it from a ring held horizontally. Then by again dipping the pipe, and passing it through the ring and into the bubble, I can blow a second bubble inside of the first (Fig. 10). It is very interesting to

20

21

see the outer bubble expanding and keeping out of the way of the inner one. The double play of colors is something magnificent. This experiment should be tried by the young folks.

Again taking a bubble on one ring, we can draw it out by another ring into shapes suggestive of the most exquisite glass vases (Fig. 11).

From a bubble suspended from a ring the air may be partially withdrawn by a pipe until a lenticular bubble—a double convex lens—is produced (Fig. 12).

I now fill a ring as before with a film. Blowing a small bubble on a pipe and touching the center of the film with it, the bubble adheres. Then by leaving the pipe stem open and cautiously drawing out or bringing the pipe closer, the mushroom-like shape you see is produced (Fig. 13).

Finally, with two rings we can get our nearest approach to an open-ended cylinder. I fill two separate rings with films, I touch them and draw them apart, the films adhering in their centers, and therefore a disk filling the opening. Now on breaking this disk with a hot wire, we have an open-ended cylindroid. A cylinder is impossible (Fig 14).

I have compared soap-bubbles to balloons. Filled with hydrogen or coal gas, they make very good ones. If the gas is pure, they rise very rapidly. By first blowing one with the breath in the usual way, and then admitting a little gas, one may be made only slightly

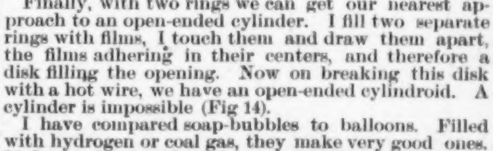

FIG. 22.

lighter than air. I shall do this, and then I shall release it. It slowly rises to the ceiling. The great point is to introduce just enough gas to float them. With pure gas they rise too rapidly for a good effect.

Having made a balloon, we may attach to it a little square piece of paper to which a thread is fastened. All that is necessary is to touch the paper with the bubble, when it adheres. By detaching it from the pipe the

bubble will rise until checked and held captive by the thread; or a miniature car may thus be attached and carried upward.

If a porous vessel full of air be closed and covered with a bell jar full of hydrogen or street gas, it is well known that the hydrogen will enter through the pores much faster than the air can get out. If the open end of the porous cup is closed with a film, the cup inverted and then covered with the jar full of hydrogen, the pressure due to the excess of gas will blow a bubble (Fig. 15). On moving the bell jar, the bubble rapidly collapses as the gas escapes from the porous cup. A similar bubble may be blown by dipping the open end of a wide-mouthed bottle in soap solution, and placing the bottle under the receiver of an air pump. On exhausting the air the bubble slowly rises from the mouth of the bottle, and on readmitting the air immediately falls back. This may be repeated several times with the same film; or a funnel tube may be dipped in the solution and then passed through the opening in the top of an air pump receiver, and secured there by a perforated cork. The least degree of exhaustion blows a large bubble that disappears as the vacuum is reduced. By closing the mouth of a metallic pipe with a film and connecting it with an excited electric machine, the electrical repulsion of the molecules will cause the film to form a bubble.

If a glass vessel is filled with carbonic acid gas and a bubble blown and dropped from the pipe so as to fall into the vessel, it will float balloon fashion upon the heavier gas, forming a pretty contrast to the gas inflated bubbles just shown you.

I cannot refrain from showing you an additional illustration of their elasticity. I will fill one with gas, and after it has attained a fair size will remove the pipe from the tube connecting it to the fixture, when we shall find that we can light the escaping gas at the end of the pipe stem, and thus form a portable gas lamp.

We have seen that a disk-shaped film is formed over a ring of metal immersed in and then withdrawn from the solution. By employing different shaped frames films of different forms, often of considerable complexity, forming warped surfaces and the like, may be produced. But as these can only be seen on close inspection I shall make a number of them, not with perishable soap solution, but with a mixture of resin and Canada balsam that forms permanent films.

Dr. Sylvanus Thompson, of the University College, Bristol, England, is the inventor of the mixture. It

Fig. 23.

must be heated in an oven or over a gas flame to the temperature of boiling water or a little higher. The frames are immersed in this for a sufficient length of time to get the wires heated, and are then withdrawn when the films form, sometimes quite slowly. It requires some niceness of manipulation to produce good films from this mixture, and they do not compare with soap films for beauty. But they last for an indefinite period.

I have six or eight frames of various shapes. I shall dip them in, and then, arranging them on this block, shall pass them to the audience, that they may inspect them more closely (Fig. 16, 17, 18, 19, 20, 21). The condition under which these are formed is simply that the film shall arrange itself so as to be of the smallest possible area under the circumstances of its lines of attachment.

Another very pretty experiment is to blow a soap bubble full of smoke. The cloud of tobacco smoke rolling about as it is inclosed in the transparent sphere presents a most interesting appearance. On letting the bubble collapse, the smoke is blown out of the open stem of the pipe. If the experimenter is not a smoker, an injector such as shown in the cut, Figs. 22 and 23, can be used. It is of the usual form, a contracted aperture jet pipe surrounded with an inclosing tube. The outer tube has a branch piece secured to it, in which a lighted cigarette or cigar may be inserted. The blast of air that inflates the bubble will aspirate air through the cigarette so as to keep it burning so as to draw thence a supply of smoke.

But the *ne plus ultra* of these fragile toys is the rainbow bubble. With very good soap solution only can it be produced. If a good sized bubble be blown with such solution, and detached from the pipe and placed upon a stationary ring or open mouth of a tumbler, it will sometimes become surrounded with a horizontal series of the most beautifully regular rings of the prismatic colors. These bubbles are the ones that last sometimes eighteen hours or more. In general terms the rings appear about half an inch wide, and there may be five or six of them arranged around the center or lower half of the bubble. A rainbow bubble indicates a good solution. If the rainbow rings do not appear, a "solid" distribution of color indicates a good bubble. One whose surface shows the shifting shades of bronze and red never at rest, and irregularly distributed, will not last two minutes; generally less than one minute.

This gives us an idea of the properties of films when isolated from the mass of fluid from which they were composed. But every such mass of fluid is bounded and inclosed by one. All fluid masses left free tend to assume the spherical form, drawn into it by their inclosing film or elastic skin. The tendency is for them to assume the shape having the smallest external bounding surface, and this form is the sphere. A drop of water hanging from the edge of a Venetian blind on a rainy day is hemispherical, held together by the film just as if inclosed in a bag of elastic material. The rain drops that produced it were spheroidal, flattened by the resistance of the air. Shot is made by pouring melted lead through perforated vessels, whence the melted metal falls in a shower of liquid spherical drops, gradually cooling and solidifying in their descent. The film surrounding each drop pulls it into sphericity. The same may be observed with globules of mercury. If a drop of water falls on a surface that it does not wet, it assumes this spheroidal form from the same cause. This may be seen on a woolen table cloth or on a hot surface.

To show it in the latter condition, I have here a cup of copper, very clean and smooth in its interior, which I have heated to quite a high temperature. If I pour water, best warmed, into it, it will not touch it, but will lie on a cushion of steam, supported by a "Crooke's layer," as it is called, and will assume the spheroidal shape, held together by the surrounding film. Thus it remains as long as the metal is hot enough to maintain the steam cushion. As the temperature falls below this point, the water comes in contact with the hot metal, and bursts into violent ebullition. This phenomenon is sometimes invoked to explain boiler explosions.

Again, we can produce this condition of things by suspending a mass of one liquid in another of the same specific gravity not miscible with it. I shall use bisulphide of carbon, colored with a little iodine, and shall suspend it in a solution of sulphate of zinc. I first pour into the flask a solution of higher specific gravity than the bisulphide of carbon. I then pour in the bisulphide, which forms a layer on the surface. On adding more zinc solution of approximately the same specific gravity, it carries up the bisulphide with it. Then water must be poured in. The surface tension of the water, combined with the tenacity of its elastic film, as its depth increases tends to lift up the heavier bisulphide, and it does this to some extent. The bisulphide gathers into a purse-like form held in a pocket of water film until the depth of water is so great that it breaks loose and falls down toward the center of the flask, a beautiful liquid sphere. Its material is drawn into that shape by the tension of its own surrounding film and the water film also.

The formation of this sphere illustrates the manufacture of shot, the shape of rain drops, and is even invoked to illustrate the method of formation of the heavenly bodies. It shows that a liquid has a film when in mass, and that in blowing a soap bubble we only isolate the film from its contents. To further emphasize this point, the experiment of floating needles may be alluded to. By gently placing needles horizontally in water, they will float. A double hook, such as is made by bending up the ends of a hair pin through about 15°, may be used to place them on the surface. As soon as one end touches, which will be known by the dimple it produces, the other end must be lowered so as also to touch. Then on lowering the hook through the water, the needle will remain floating in a little depression or dimple. Now we know that this dimple is not large enough to account for the floating by the water displaced. The needle is sustained by the combined tension and tenacity of the water film, just as if a sheet of India rubber were tightly drawn across the vessel containing the water. The surface of water may be dusted over with lycopodium, and a magnetic needle be poised so as to have its lower surface in contact with the water. If caused to move by a piece of iron, the whole surface, as shown by the lycopodium, will move with it. It carries the film round and round with itself, not breaking it.

For producing large bubbles, a funnel of three or four inches diameter is good. As the blowing of anything over six or eight inches in diameter is quite exhausting, a bellows should be used for the large ones. By taking up a quantity of suds in the hands joined trumpet fashion, and blowing into the cavity, quite large bubbles can be produced.

FILM MIXTURES FROM VARIOUS SOURCES.

I. For soap bubble solution the best material is pure oleate of soda. Oleic acid as sold in the shops is far from reliable, containing one or more other fatty acids, such as stearic acid. To make the pure acid, two ounces of pure soap (almond oil is the best, but Castile will answer) are dissolved in twenty ounces of boiling water. One ounce of sulphuric acid previously diluted with two ounces of water and allowed to cool is added. The fatty acids rise to the surface in an oily layer. The water is siphoned off, and they are washed three times with boiling water. The mass is allowed to cool, and is removed from the surface of the water, where it floats. It is weighed, mixed with one-half its weight of litharge, and heated (212°-225° F.) until complete combination is effected. This may be known by the cessation of any evolution of bubbles from the mass. The resulting "lead plaster" is allowed to stand mixed with ten to fifteen times its weight of ether in a tightly corked bottle until completely disintegrated. Then it is filtered, and to the filtrate hydrochloric acid is added as long as any lead is precipitated. The ethereal solution is poured off, and the ether recovered by distillation, leaving pure oleic acid. Two fluid drachms of the acid is added to somewhat less than a pint of boiling water, and solution of caustic soda very carefully added drop by drop until complete solution of the acid is effected, very carefully avoiding an excess of soda, and after cooling water is added to make it measure just one pint. A standard soap solution is thus obtained. To this add one-half its bulk of the best glycerine (Scheering & Glatz's, or Price's). Shake long and well, and the mixture is ready for use.

II. Take of Castile soap 75 grains, dissolve in 4 drachms of distilled water, and filter. To every three parts by measure add two parts of glycerine; shake and allow to stand before using.

III. Plateau's mixture.—The preparation must be executed in a warm room, not colder than 68° F. in the daytime at least. One part (by weight) of recently made Marseilles soap is dissolved in forty parts of distilled water at a moderate heat. When the solution has sunk nearly to the temperature of the room, it is filtered. Three volumes of this solution are mixed with two of Price's glycerine (15 parts to 11 parts is sometimes given), poured into a flask, and vigorously shaken, and for a long time. The mixture is allowed to stand for seven days. On the eighth day it is cooled in ice water to about 37° F., and kept at this temperature for six hours. It is then filtered through very porous paper. With ordinary paper it can hardly be made to pass by any amount of waiting. The contents of the filter must be kept cold by doing the work in the ice chamber of a refrigerator or by keeping a stoppered tube full of ice in the funnel. The bottom of the flask into which the liquid drops is surrounded by ice. The first portions are turbid; they are poured back, and eventually a perfectly clear solution is obtained. After all the work, if the soap and glycerine are not good, the bubbles from the mixture will often last only a few minutes. They should last eighteen hours in the open air, supported on a horizontal ring previously moistened with the same solution. The above mixture must be filtered through very porous paper.

IV. Dissolve two ounces of palm oil or Castile soap in a pint of rain water, previously cutting the soap into small pieces. Shake until all is dissolved that the water will take up. Let it stand from twenty-four to thirty-six hours. If settled, carefully pour off the clear solution through flannel. If it does not settle, pour off some of the cloudy solution and add more water. Then it will hardly fail to settle. To one volume of the clear solution add one-half a volume of pure glycerine.

V. Dissolve a piece of glycerine soap finely sliced in rain water at 110° F. (Not reliable.)

VI. Collodion film mixture.—Ether (by weight), 89 parts; absolute alcohol, 5½; photographic guncotton, 5½; dissolve and decant. To 100 parts of the clear solution add 70 to 100 parts pure castor oil. This makes permanent films, but not as satisfactory ones as those given by the rosin mixture.

VII. Rosin film mixture.—Rosin, 46 parts (by weight); Canada balsam, 53 parts; melt together, and add a few drops of turpentine. In using, heat a little over the boiling point of water. The higher the heat, the thinner and better the films; but with too hot a mixture they are not permanent.

Note.—Almond oil soap is probably the best of the commercial soaps, or as good as any. The writer has never tried it. Holbrook's Gallipoli soap, (of Washington Street, N. Y.,) treated by Plateau's method, makes an excellent mixture. It is the only soap with which we could ever produce a rainbow or even a lasting bubble. Schering & Glatz's glycerine is perfectly satisfactory. Glycerine is frequently adulterated with glucose. Such is useless. Marseilles soap, such as can be bought in this city, or Holbrook's brown oil silk soaps make a fair mixture. Plateau's process is the proper one to follow. Oleate of soda is generally considered to make the best. Sometimes sugar solution is recommended instead of glycerine, but this recommendation should not be followed.

A RECENT CASE OF HYDATIDS.

With the desperation of one afflicted with an incurable disease, a well developed young man about 30 years of age, and standing over six feet in height, recently visited nearly all the physicians of any eminence in this city. The same fatal verdict was unreservedly passed upon him at every visit, viz., that he was suffering from an internal cancer, or rather series of cancers, which seemed to fill the abdominal cavity, involving all the vital organs therein situated. He was told that cure was out of the question, even by an operation, that his life would be limited to a few months, and advised to enjoy the brief period to the best of his ability.

He still, however, maintained his pilgrimage of the medical profession, and at length was examined by Prof. Seneca D. Powell, M.D., of the N. Y. Post-Grad. School of Medicine, who carefully studied the case, and eventually came to the conclusion that the patient was suffering from one of the most terrible of all parasitic diseases, known as "*hydatids*." This disease, which has spread with such appalling rapidity in Iceland that out of a population of 60,000 persons, 10,000 are said to be under treatment at the same time, is almost unknown in Europe and the United States.

This diagnosis brought but small comfort to the unfortunate patient, for malignant cancer and hydatids were both incurable and fatal diseases; still there was the faint hope with the latter trouble that there was one chance in a thousand that a skillful and successful operation *might* give him the respite of a few years.

With a full knowledge of all the facts of the case and the attending risks, the young man consented to place himself in the hands of Dr. Powell, and arrangements were made for the operation at an early day.

But what an operation! for it involved the necessity of making abdominal sections similar to the awful

Cæsarean operation, from which few survive, but even of a more dangerous character, from the length of time needed in the present case. Fifteen leading New York surgeons, including Dr. James Little (since deceased), Dr. Frank Hamilton, and Dr. Sims, stood around the patient and freely canvassed the case, expressing grave doubts if he would ever leave the operating table alive. But a deathlike silence ensued as all, including the writer, watched with bated breath the little sharp pointed knife of Dr. Powell, as it slowly made the section. The greatest caution was employed, and with an opening of about two inches, a halt was

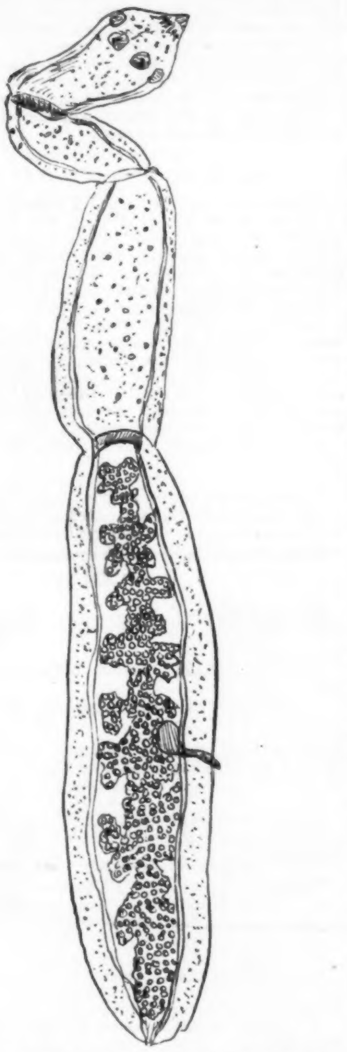

FIG. 1.—THE MATURE TÆNIA ECHINOCOCCUS. Hitherto found only in the dog and allied species. Average size, ¼ of an inch. It has four segments, including the head.

called and an exploration made. Was it cancer or hydatids? Dr. Powell at once produced a small bladder-like cyst, the size of a nut, which settled the medical question in favor of his diagnosis of hydatids.

I draw the veil over what followed, except to say that the incision was enlarged to a fearful extent, and for two mortal hours the hands of the operator were plunged in the abdominal cavity, removing over one hundred and fifty of these bladder-like watery crysts, each containing thousands upon thousands of the parasites. Who could have thought that any human being could have survived such horrible mutilation continued for hours? but such had been the skill of the operator that by the third hour the patient was through all his troubles, restored to consciousness from the long effect of the ether, conversing with those around the operating table, and was carried, feeling quite comfortable, to his bed. I need not say that Dr. Powell received from his medical brethren present their hearty

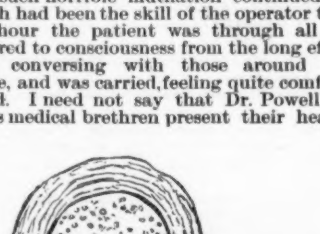

FIG. 2.—EARLY STAGE OF HYDATID.

congratulations for having achieved one of the greatest triumphs of surgical art that has been witnessed in this country.

To briefly end this history, I must state that the patient, to the surprise of all, slowly but surely mended until the fourteenth day, and was considered out of danger, when, by a fatal act of imprudence, by actually leaving his bed, he brought on a collapse, which killed him in a few hours. Since this case two others have come to my knowledge, one at Philadelphia, which was similar in its gravity to the one here described, and another at Newark. In all three cases the diagnosis by the medical profession (Dr. Powell excepted) was that of cancer, and the truth of each case was only demonstrated on the operating table. There can be little doubt therefore that many cases of supposed cancer are really of hydatid origin, the symptoms and appearances of both diseases being so similar that the medical profession are unable to distinguish one from the other, the preference being given to cancer, as the other disease is supposed not to exist in this country except in very rare instances.

"Hydatids" being, then, among us, and being the most dreadful of all internal parasitic diseases, throwing into the shade the horrors of trichina itself, a few words on the subject may be of service to those who

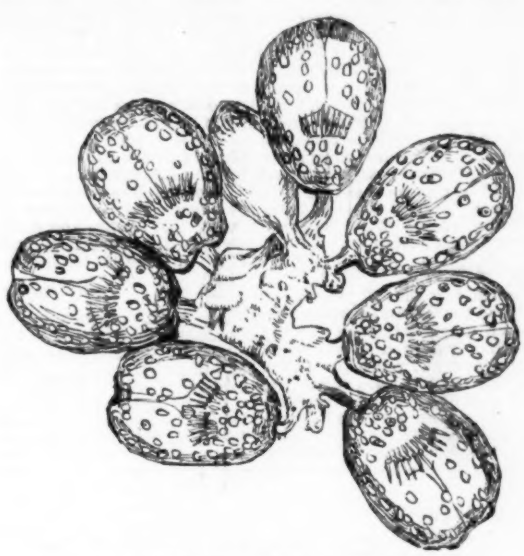

FIG. 3.—GROUP HYDATID SCOLICES.

would avoid death by such means, especially as the simple act of drinking a glass of water or nursing a favorite dog may make a person instantly the host of this parasite.

Among the twenty-one internal parasites which infest dogs there is one called Tænia echinococcus, and in Iceland twenty-eight per cent. of the dogs are found to be harboring this entozoon. This parasite is a minute, little tapeworm with three joints, being only a quarter of an inch in length in the mature adult form. Its life history has three phases: the ova or egg; the intermediate or larval form (called hydatids); and the perfect parasites. It is a curious fact that, while the adult form will mature only in the dog, the larval

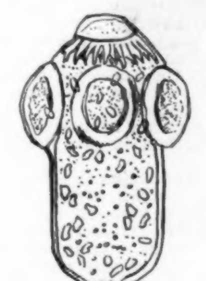

FIG. 4.—SINGLE HYDATID SCOLEX.

type will develop and multiply in the human body, but never gets beyond this stage.

One of the joints of the adult parasite in the dog contains the sexual parts, which, is capable of developing from five to six million zooids, which in their turn can produce 150,000,000,000 ova.

Such being their prodigious powers of propagation, one can imagine the position of an unfortunate human being who has become the host of this parasite.

Infection may occur in many ways; the adult form or the ova is continually thrown off from dogs with their excreta, and also from the mouth. Drinking water used from a supply in which dogs drink or wade is of course dangerous; the practice of allowing dogs to lick the lips, a common practice with pet dogs, or allowing

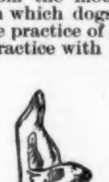

FIG. 5.—A SINGLE HOOK.
These vary in size from $\frac{1}{1000}$ to $\frac{1}{1750}$ of an inch.

dogs to sleep in or upon a bed, may lead to infection. The danger of too close contact with dogs is seen in the result in Iceland, where every peasant on an average has six dogs, and it is found that one-sixth of all who die in that country die of the hydatid disease.

Let us suppose that a human being is infected: the first place in which the hydatid is found would probably be the liver; from here they pass to the abdominal cavity, entering each organ there, and they have also been found in the spinal cord, brain, heart, kidneys, in fact all over the body. These hydatids have the power of forming cysts, or thick-skinned bladders, which increase in size until they are as large as a man's fist. These cysts are filled with a clear, transparent water. No wonder, then, that the organs attacked are increased to an immense size, and the abdomen extended to a fearful extent. There is no inflammation, and little pain except from the discomfort, but later the pressure on the vital organs creates great suffering. The patient may continue alive for quite a time, as the growth is very slow and gradual, but in the later stages he becomes a misery to himself and those around him and a mystery to his medical attendant, who probably treats the case as one of cancer or internal tumor. Temporary relief has been afforded in some cases by a surgical operation, which must be undertaken quite early in the case to be of any service. Dr. Cobbold, the noted authority on entozoa, fears cases of the disease are rapidly on the increase in England; but as only a post-mortem examination can reveal the truth, no estimate can be made. He says he has traced four hundred deaths in one year. Here we have in this country three cases within a few weeks actually demonstrated by the knife.

As prevention is better than cure, I would advise that all doubtful drinking water be boiled and filtered, and that those who have dogs should keep them at a safe distance and as much out of the house as possible.

JOHN MICHELS.

New York, June, 1885.

NOTES ON THE PERIODICAL CICADA.*

By C. V. RILEY.

Just at this time a very considerable interest is manifested in this curious insect, because of the concurrence of the two extensive broods, the one belonging to the typical *septendecim* form, the other to the *tredecim*. These two broods appeared simultaneously in 1664, and will not concur again till the year 2106. The following are the localities in which these two broods will respectively occur.

BROOD VII. TREDECIM. (1872, 1885.)

Illinois.—Jackson, Union, Macoupin Counties.
Missouri.—St. Louis, Boone Counties.
Georgia.—DeKalb, Gwinnett, Newton Counties.
Tennessee.—Madison County and northern portions of the State.
Mississippi.—Copiah County, Oxford, and eastern portion of the State.
Louisiana.—Carroll Parish.
Kansas.—Phillips County.
Arkansas.—Flat Bayou.

The existence of this brood has been verified in past years in the parts of Illinois, Missouri, Tennessee, Mississippi, and Arkansas indicated, but the localities in Kansas, Georgia, and perhaps Louisiana, require further confirmation this year.

BROOD XXII. SEPTENDECIM. (1868, 1885.)

New York.—Kings, Monroe Counties.
Massachusetts.—Fall River, southeast portion of the State.
Vermont.—Rutland.
Pennsylvania.—Lancaster.
Ohio.—Green, Franklin, Columbiana, Pike, Miami Counties, and vicinity of Toledo.
Indiana.—Tippecanoe, Delaware, Vigo, Switzerland, Hendrick, Marion, Dearborn, Wayne, Floyd, Jefferson Counties.
Michigan.—Southeastern portion.
Delaware.—Very generally.
Maryland.—Very generally.
District of Columbia.—Very generally.
Virginia.—Very generally.
Kentucky.—Around Louisville.
Georgia.—Habersham County.

The object of the few remarks I shall make to-night is not so much to restate what has already been said about this insect as to give some unpublished experience that may prove of interest to the society.

A full account of the insect was given in my first report as State Entomologist of Missouri in 1868, the year of the last preceding appearance of the *septendecim* brood, and I am just about to issue a revised edition of that article, with such additional chronological data as I have been able to accumulate during the intervening 17 years.

In the 1868 article I established the existence of a number of 13-year broods, some of which had been recognized by Dr. G. B. Smith, of Baltimore, in an unpublished manuscript, and one of which, as I subsequently learned in 1873, had been recorded many years

* Read before the Biological Society of Washington, May 30, 1885.

before, or in 1845, by Dr. D. L. Phares, of Woodville, Miss.

THE SPECIFIC VALUE OF THE DIFFERENT FORMS.

While some writers have contended that the *septendecim* and *tredecim* forms constitute distinct species, notwithstanding the external resemblance of the insects composing them, I would here reiterate the opinion which I first expressed, that they should be looked upon as one and the same species. Except for the difference in time required for underground development, they are absolutely undistinguishable. There is also a smaller, darker form issuing somewhat later than the main broods, which is found in connection with both.

This form was described as *Cicada cassinii* by Dr. J. G. Fisher, in the Proceedings of the Philadelphia Academy of Natural Sciences for 1851 (vol. v., pages 272-3). There is some slight difference in the male genitalia of this smaller as compared with the more typical form, but I have found considerable variation in this regard, and especially in the *cassinii* or smaller form, and it is the conviction of those best competent to judge that *cassinii* should be regarded as merely a dimorphic variety. The species should be thus catalogued: *Cicada septendecim* Linn. Race *tredecim* Riley. Dimorphic variety *cassinii* Fisher.

THE LONG PERIOD OF UNDERGROUND DEVELOPMENT.

From chronological data the fact that 17 years or 13 years are respectively required for the underground development of this insect, according to the race, is fully established, one of the first recorded *septendecim* broods having been observed every 17 years since 1715. Such anomalous and exceptional facts in natural history, as witness the discussion as to the egg laying of ornithorhynchus, always provoke skepticism, and the facts recorded regarding our Cicada's hypogean life have shared in this tendency. Hence a few biological facts, especially such as bear on the development of the larva, will not prove uninteresting.

THE FACTS IN ITS LIFE-HISTORY.

I took pains to follow the larval development, as far as possible from year to year, of the tredecim brood which appeared in 1868, my observations having been made in St. Louis County. Repeated efforts to rear the young larvæ in confinement proved unsuccessful, and it was necessary to resort to careful and repeated digging out-doors in order to watch the growth from year to year. One of my employes at Cadet, Mo., has also been instructed to carefully pursue the same subject, and I have repeated the digging since residing in Washington. These observations have in all cases been made in special localities, where the date of entering the ground was well known and observed. I have thus been able to follow the larvæ for the first six years with great care, and for subsequent years with less care and continuity. As we might expect from the chronological history of the species, the development of the larva is extremely slow, and at six years old it has hardly attained one-fourth of its full size. Another interesting result is that, notwithstanding this slow development, moulting takes place quite frequently, *i. e.*, the number of larval stages is more than one per annum, and probably 25 or 30 in all; whereas in the Homoptera generally—the suborder to which the Cicada belongs—it ranges from 2 to 4. In any hypogean insect which continually uses its claws in burrowing, the need of shedding and renewal of these organs is apparent, and may afford the chief explanation of this repeated exuviation, though the slow development is a factor, since my own experience has shown, in the larvæ of the other orders, that in proportion as development is slow, exuviation is frequent.* The changes with each moult are, in our young Cicada, most noticeable in the antennæ and the front legs and their armature, for the general form undergoes but little change, the body very gradually shortening and thickening and the color darkening with age. One fact of considerable scientific interest may, however, be stated, viz., that after the first few moults the front tarsi are lost entirely and regained only during the few later stages. In other words, as the claws of the front tibiæ are the chief instruments used in burrowing, the tarsi become useless or obstructive, and are gradually reduced and finally lost. They are then regained suddenly during one of the later moults, but are so articulated that they are thrown back on the inside of the tibiæ, and form a good brace for strengthing these. They are thus out of the way for underground work, and come into use only, with their well preserved claws, when the pupa issues from the ground and ascends for the final change.

THE FOOD OF THE LARVA.

A good deal of difference of opinion has been expressed by different writers as to the food of the Cicada larva, and this is not to be wondered at, from the fact that there is great difficulty in observing it feed. Dr. G. B. Smith insisted that it obtained its nourishment from the moisture of the earth through capillary hairs at the tip of the proboscis, while many others have seen it with its beak inserted in the roots of trees and pumping the sap therefrom.

The former method is insisted on by Dr. Smith from his own observations; but while I think it is not improbable, especially during its earlier larval life, that the Cicada may feed on earth exudation—a belief which receives support from the well known fact that this Cicada will issue from ground that has been cleared of timber and cultivated for nearly 17 years, and that other species are known to issue from the prairies—the liquid is evidently pumped up in the ordinary way. The truth of the matter seems to be that the Cicada larva can and does go for long periods without nourishment, where such fasting is necessitated, and that in the earlier years of its development, more particularly, it feeds on the rootlets or radicals not alone of trees, but of herbaceous plants. In my own observations I have rarely found it more than two feet below the surface during the first six or seven years of its life, and almost invariably in an oval cell, and more often away from roots than near them. Yet I have also found it with beak inserted, and it will often hang fast by the beak after being unearthed. That the larva is capable of going to great depths is well attested by observers, and I have recently received a communication where the writer says he has found it 20 feet below the surface. It is difficult to say how many of such reports are based on the unobserved tumbling of the larva from higher levels; but where the insect has been observed to issue from the bottoms of cellars ten feet deep, the information would certainly seem to be reliable.

METHOD OF BURROWING.

The method of burrowing and making its cells is quite interesting. With the strong front tibial claws it scratches away the walls of its cell just as one would do with a pick; and if it is rising so that the earth removed naturally falls to the posterior end of the burrow, it simply presses the detached portions on all sides, and especially on the end of the cavity, by means of its abdomen and middle and hind legs. If, however, it is burrowing downward and the loose soil has to be pressed against the tip of the cavity, it uses its broad front femora very dexterously in making a little pellet of the soil and in placing it on the clypeal or front part of the head, when the load is carried up and pressed against the top of the cavity.

The motions made in cleaning its forearms remind one very forcibly of those made by a cat in cleaning its face. The femora and bent tibiæ are rubbed over the clypeus, the numerous stiff hairs on which act like a comb or brush in freeing the spines of dirt.

THE TRANSFORMATIONS.

As the time approaches for the issuing of the pupa, it gradually rises nearer and nearer to the surface, and for a year or two before the appearance of any given brood this pupa may be dug up within one or two feet of the surface.

In the year of their ascent, from the time the frost leaves the ground they are found quite close to the surface, and also under logs and stones, seeming to await the opportune moment, and apparently without feeding. They begin to rise from about the 20th of May in more southern localities, and but little later further north. Here in Washington, the present year, they began to sparsely issue about the 23d, and were, perhaps, most numerously rising on the night of the 27th. Those in the city were somewhat earlier than those in the woods just over on the Virginia side. The unanimity with which all those which rise within a certain radius of a given tree crawl in a bee-line to the trunk of that tree is most interesting. To witness these pupæ in such vast numbers that one cannot step on the ground without crushing several, swarming out of their subterranean holes and scrambling over the ground, all converging to the one central point, and then in a steady stream clambering up the trunk and diverging again on the branches, is an experience not readily forgotten, and affording good food for speculation on the nature of instinct. The phenomenon is most satisfactorily witnessed where there is a solitary or isolated tree.

The pupæ begin to rise as soon as the sun is hidden behind the horizon, and they continue until by nine o'clock the bulk of them have risen. A few stragglers continue until midnight. They instinctively crawl along the horizontal branches after they have ascended the trunk, and fasten themselves in any position, but preferably in a horizontal position on the leaves and twigs. In about an hour after rising and settling, the skin splits down the middle of the thorax, from the base of the clypeus to the base of the metanotum, and the forming Cicada issues.

Ecdysis is always an interesting phenomenon, and when closely watched in our Cicada, cannot fail to entertain.

The colors of the forming Cicada are a creamy white, with the exception of the reddish eyes, the two strongly contrasting black patches on the prothorax, a black dash on each of the coxæ and sometimes on the front femora, and an orange tinge at base of wings.

There are five marked positions or phases in this act of evolving from the pupa shell, viz., the straight or extended, the hanging, head downward, the clinging, head upward, the flat-winged, and finally the roof-winged. In about three minutes after the shell splits, the forming imago extends from the rent, almost on the same plane with the pupa, with all its members straight, and still held by their tips within the exuvium. The imago then gradually bends backward, and the members are all loosened and separated. With the tip of the abdomen held within the exuvium, the rest of the body hangs extended at right angles from it and remains in this position from ten to thirty minutes or more, the wing pads separating and the front pair stretching at right angles from the body, and obliquely crossing the hind pair. They then gradually swell, crimp, and curl until they form a more or less perfect loop, and during all this time the legs are becoming firmer and assuming the natural positions. Suddenly the imago bends upward with a good deal of effort, and clinging with its legs to the first object reached—whether leaf, twig, or its own shell—withdraws entirely from the exuvium, and hangs for the first time with its head up. Now the wings perceptibly swell and expand until they are fully stretched and hang flatly over the back, perfectly transparent with beautiful white veining. As they dry they assume the roofed position, and during the night the natural colors of the species are gradually assumed.

The time required in the transformation varies, and though from the splitting of the skin and the full stretching of the wings in the flat position the time is usually about twenty minutes, it may be, under precisely similar conditions, five or six times as long. But there are few more beautiful sights than to see this fresh forming Cicada in all the different positions, clinging and clustering in great numbers to the outside lower leaves and branches of a large tree. In the moonlight such a tree looks for all the world as though it was full of beautiful white blossoms in various stages of expansion.

THE CICADA VERSUS CIVILIZATION.

That this insect, in its distribution and in its numbers, has been and is being seriously affected by our civilization must be apparent to every observer. The records show that the numbers have decreased in the successive appearances of certain broods, owing largely to the presence of our domestic animals in the woods. Then again the clearing of land and the building of towns and cities have all had their effect upon the increase of this Cicada. There are doubtless many places in Brooklyn, N. Y., where the insect appeared 17 years ago in which there will be none the present year. And similarly I opine that, whereas around every tree that has been planted more than 17 years or upon land that grew trees 17 years ago, the insect is now abundant in Washington, it will scarcely be noticed in any part of the district 17 years hence. I base this opinion on a new phase in the Cicada history, viz., the presence of the English sparrow. It is the first time, perhaps, in the history of the world that *Passer domesticus* has had an opportunity of feeding upon this particular brood of *Cicada septendecim*, and so ravenously and persistently does this bird pursue its food that the ground is strewn with the wings of the unfortunate Cicada wherever these have been at all numerous; so that considering the numbers of the sparrow and their voracity, very few of the Cicada will be left long enough to procreate and perpetuate the species in the District.

[The close of the paper considered the subject of variation in the appearances.]

* Vide *Am. Naturalist*, 1883, p. 547.

GROOVED BED FOR GAS PIPES.

AT the meeting of the North of England Gas Managers' Association, Mr. J. Hull, in speaking of mains and service pipes, said that "one of the greatest apparent evils in laying pipes is their being laid too near the surface of the ground; and it does not matter what the joint may be, in course of time, owing to the upheaving and settling of the ground by frost, weather, and top pressure of traffic, the joins will slacken and become loose." After using service pipes of cast iron, malleable iron, and lead, the author gives the preference to lead. "No choking takes place through rust or any other matter." The chief difficulty he had to encounter was to get the lead services straight, and prevent bagging and collecting water. They finally adopted a half-grooved tube of red pine, in which the pipe rests.

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TABLE OF CONTENTS.

PAGE

I. CHEMISTRY.—Liquefaction and Solidification of Formene and of Nitric Oxide.—By K. OLZEWSKI 7901

II. ENGINEERING AND MECHANICS.—Merchant Vessels as Armed Cruisers.—Full page of engravings 7896
Torpedo Boats in War 7895
Amateur Mechanics.—Lens making.—10 figures 7897
Rapid Smelting Plant.—4 figures 7900

III. TECHNOLOGY.—Tempered Glass.—A paper lately read before the Society of Arts, with discussion following the same 7897
Purification for Industrial Purposes 7899

IV. ART AND ARCHITECTURE.—Theseus Conquering the Centaur.—An engraving 7901
Proposed House, Beckenham Park.—An engraving 7901

V. PHYSICS.—The Physics of Tenuity.—A lecture on soap bubbles.—Numerous experiments.—Film mixtures from various sources.—By T. O'CONOR SLOANE 7902

VI. BIOLOGY, ETC.—Notes on the Periodical Cicada.—By C. V. RILEY.—Specific value of the different forms.—Facts in its life history.—The transformation.—The Cicada versus civilization 7906

VII. HYGIENE, ETC.—A Recent Case of Hydatids.—Treatment of the disease.—Cause, etc 7904

The Scientific American Supplement. Index for Vol. 19.

JANUARY–JUNE, 1885.

The * Indicates that the Article is Illustrated by Engravings.

A

Academy of Sci., Nat., papers at, 7828
Accumulator, auto., Jablochkoff's .. 7868
Achilles, the Dying ... *7754
Acid, stearic, apparatus ... *7563
Acid, sulphurous ... *7704
Acid, fat, conversion of ... 7824
Acid troughs, cement for ... 7699
Acids, mineral and solid ... 7560
Actinometer, new ... 7727
Æolian harp ... *7715
Aerial navigation ... *7816, 7864
Aerial navigation, apparatus ... *7826
Aerial telegraphy ... *7579
Aerifilter ... *7806
Aerostation, Military ... 7770
Agamemnon, ship ... *7647
Age, old, suspension of ... 7825
Air, compressed, building by ... 7654
Air gun experiments ... 7566
Alabaster soap ... 7562
Albo-carbon lamp ... *7839
Albunuelas, ruins of ... *7653
Alcohol, alluring properties ... 7570
Alexandrine, Corvette ... *7771
Alkilinity of photo salts ... 7739
Alkaloids, poisonous, in cholera ... 7700
Almond soap ... 7887
Almond spirit ... 7536
Alphabet, Egyptian ... *7572
Alphabet, Maya ... *7572
Alphabet of deaf and dumb ... *7667
Alphabet, ornamental ... *7728
Alum for purifying water ... 7842
Aluminum, extraction of ... 7824
Amateur mechanics ... *7897
Ambergris, tincture ... 7536
America, zinc statue of ... *7697
Ammonia, production of ... *7757, *7776
Ammonia in blood poison ... 7598
Ammoniaphone, the ... *7843
Amperemeters, calorimetric ... *7568
Amusements, scientific ... *7716
Anæsthetics ... 7602
Anæsthetic gases, table of ... 7603
Anchor gear, Baxter's ... *7771
Anemometer, Biram's ... *7805
Anemometer, Davis' ... *7805
Aniline dyes in dress goods ... 7505
Animals, painless extinction of ... 7672
Animals, sex regulation ... 7893
Ant, leaf-eating ... 7669
Antwerp Exposition ... *7797
Apes, habits of ... 7892
Aqueduct, Croton, new ... *7517, 7519
Archæology, Mexican ... 7781
Architecture, infl. of wood on ... 7751
Architecture, suggestions in .. *7552, *7559, *7754, *7885, *7901
Arizona, ship ... *7905
Arlberg Tunnel ... 7801
Armor plates, trial of ... *7689
Armor, 17th century ... *7776
Art, ancient Mexican ... 7782
Art, decorative, suggestions .. *7534, *7610, *7728, *7729, *7901
Art of breeding ... 7798
Art in sheet metal ... *7697
Arts, mechanic, foreign, etc ... 7656
Artesian well, Fort Scott ... 7608
Artesian wells, Pomona ... *7521
Artillery, Spanish ... *7847
Asbestos ... *7741
Ash, of vegetable liquids ... 7606
Asphalt roofs ... 7885
Assyrian science ... 7572
Astronomical photography ... 7728
Astronomical telescopes, progress *7735
Attock Bridge ... *7500
Australia, ship ... *7895
Avalanche in Northern Italy ... *7701

B

Baboons, habits of ... 7892
Bacillus amylobacter ... *7621
Balloons and lightships ... 7880
Balloons, hot air principle of ... *7860
Balloon, Petersen's ... 7684
Balloon, lenticular ... *7831
Ballooning, Military ... 7770
Bank notes, flora of ... *7813
Bark, Tanekaha ... 7605
Barometer, camphor, the ... 7893
Barometer, glycerine ... *7894
Battery, atmospheric ... 7495
Battery element, iron as ... 7808
Battery, secondary, new ... 7883
Batteries, Fitts' ... 7854
Batteries, voltaic ... 7713
Bay Rum ... 7761
Bear, skeleton of ... *7718
Beef, how cut up ... *7542
Beer, Pasteur's researches ... 7570
Bells, signal ... 7496
Benzine, tincture ... 7536
Bessemer plant, small ... 7848
Billroth, Theodor ... *7703
Bird charmer ... *7780
Birds, lyre, notes on ... 7588
Blaauw Krantz Viaduct ... *7719
Blast-furnace slag refining ... 7561
Blocks, fixing, fireproof ... *7600
Blood poison, ammonia in ... 7598
Blood, transfusion of ... *7568
Blow pipe flame furnace ... *7527
Boats, torpedo, in war ... 7896
Boats, torpedo, winch for ... *7723
Bohlig, Ernest, gymnast ... *7844
Boiler, marine, transporting ... *7803
Boiler plates, measuring thickness .. 7854
Boiler plates, steel ... 7815
Boiler scale, electricity vs ... 7728
Boiler, soda, the ... 7800
Boilers, effect of oil in ... *7803
Boilers, feeding at the bottom ... *7707
Boilers, steam ... 7800
Boiling points, liquids and gases ... 7807
Boone Cave in Pennsylvania ... 7541
Boots, machine to polish ... *7677
Borax for internal use ... 7805
Borax soap ... 7887
Bottle explosions ... 7638
Bouquet de Caroline ... 7760
Bouquet Fedora, extract ... 7760
Bouquet Ristori ... 7761
Bower-Barff iron ... 7625, 7885
Bowling alley, circular ... *7795
Bowstring girder, stresses in ... *7711
Brassica oil ... 7779
Breakers, stopping with oil ... 7592
Breeding, the art of ... 7798
Bridge at Verona ... *7849
Bridge, Attock ... *7500
Bridge, Blaauw Krantz ... *7719
Bridge construction, progress ... *7785
Bridge, Forth ... *7627
Bridge, Niagara ... *7687
Bridge, proposed, over Thames ... *7688
Bridge, railway, pontoon ... *7565
Bridge, tower, design for ... *7879
Brighton College ... *7559
Brocken, winter scenes on ... *7780
Bronze ... 7799
Bronze age, Mexico in ... 7781
Bronze casting ... 7872
Brown Windsor soap ... 7887
Bubbles, soap, experiments ... *7902
Buddhist theory of evolution ... 7652
Building by compressed air ... 7654
Building, fireproof, New York ... 7884
Building material, concrete as ... 7774
Buildings, market, movable ... *7788
Buildings, noted, height of ... *7577
Buildings, shoring of ... *7753
Buildings, steam heating ... *7772
Buoy, bell, Brown's ... *7496
Buoys, whistling ... *7496
Burner for sulphur ... *7704
Burner for water gas light ... *7871
Burring arrangement, improved .. *7582
Burrs, machine to remove ... *7582

C

Cabbage oil ... 7793
Cable and surface railroads ... *7769
Cables, electric, new ... *7762
Cactus, group of ... *7557
Calcining furnaces, revolving ... 7601
Calls, telephone, relay for ... *7808
Camellia oil ... 7779
Camera for photographing larynx *7555
Camera lucida, Schröder's ... *7514
Camphor barometer, the ... 7893
Camphor oil, Japanese ... *7552
Canada and the U. S. visit to ... 7678
Canadian Pacific Railroad ... 7721
Canal, elevator for ... *7608
Canal improvements ... 7786
Canal, Panama, dredges on ... *7591
Candle machines ... *7562
Candles, manufacture of ... *7562
Canning fruit in London ... 7633
Cannan, Hotchkiss ... *7865
Cantilever bridge, Niagara ... *7687
Capillary tube, chemical action ... 7662
Capstan navigation ... *7722
Car, dumping ... *7578
Car horses, care of ... 7653
Car motor, spring ... 7711
Car of ship railway ... *7639
Car propeller, Cole's ... *7548
Car varnishes, testing ... 7502
Car wheels, casting ... *7712
Carbon bisulphide ... 7603
Carbon disulph., antiseptic ... 7542
Carbon in phosphorus ... 7616
Carbon, sulphide of ... *7704
Carbonic oxide ... 7602
Carriages, electric lighting ... *7868
Cars, heating ... *7632
Cars, spring motors for ... *7548
Casino at Monte Carlo ... *7860
Cassie, essence of ... *7536
Cast iron, remelting ... 7580, 7707
Cast iron, to harden ... 7588
Casting bronze ... 7872
Casting car wheels ... *7712
Castings, sound ... 7688
Catamaran, May Barrett ... *7529
Catamaran, steam ... *7529
Cathedral of Incarnation ... 7787
Cathedral, Southwall ... *7877
Cattle market, Vienna ... *7592
Cave, bone, Pennsylvania ... 7541
Cave, Fingal's ... 7706
Cave, Marble ... 7586
Cedron seed ... 7806
Cells, selenium, properties ... 7856
Cement mortar, influence of sand ... 7576
Cement, slag ... 7698
Cement, uses of ... 7787
Cement, special ... 7699
Centaur, conquering the ... *7901
Chair leather, embossed ... *7610
Channel Tunnel ... 7598
Charmers of birds ... *7780
Chemical action, capillary tube ... 7662
Chemical equivalents, to determin. *7823
Chimpanzee, habit of ... 7893
Chinese pump ... *7672
Children's Home, Linden ... *7748
Chlorides, spark spectra of ... 7627
Chloroform ... 7602
Cholera, alkaloids in ... 7700
Cholera, fowl ... 7570
Cholera, foudroyant ... 7873
Cholera, how spread ... 7703
Cholera microbe ... *7586
Cholera, what we know of ... 7519
Chrysanthemums ... *7523
Church, votive, new ... *7751
Cicada, periodical ... 7905
Circle divider ... *7706
Cisterns, cement lining for ... 7699
City Hall Park, Vienna ... *7610
City telegraph wires ... 7878
Civet, tincture ... 7536
Civilization and eyesight ... 7065
Civita Lavinia, discoveries at ... *7541
Clepsydra ... *7673
Clock, water ... *7673
Cloth tentering machine ... *7662
Cloud-glow apparatus ... *7812
Clouds, electricity from ... *7867
Clove, pink, extract of ... 7537
Cloves, spirit of ... 7536
Coal, ammonia from ... *7757, *7776
Coal gas for lethal purposes ... 7603
Coal mine railway, electric ... *7580
Coal, origin and structure ... *7681
Coal, sections of ... *7682
Coal staith, Butler's ... *7515
Coast of Sweden, rise ... 7511
Coasting sled, New England ... *7594
Coca ... 7861
Coca plant, Culture of ... 7606
Cocaine, preparation of ... 7540
Cola nut ... *7606
Coldness, warmth, pressure ... 7883
College, Brighton ... *7559
Cologne, Farina ... *7760
Cologne, West End ... 7761
Colorimetric voltameters ... *7568
Colossus, H. M. S ... *7799
Columbus, zinc statue of ... *7697
Combers, Heilmann's improved ... *7676
Complexion powder ... 7761
Concrete as building material ... 7774
Condenser, Wallich's ... *7582
Conductors, electric, new ... *7762
Conduction and induction ... *7745
Cooking, sanitary ... 7730
Copper, electrolytic ... *7623, *7646
Copper in canned peas ... 7502
Copper matte, electro tr'tm't, *7623, *7646
Copper wire, drawing ... *7516
Cord, to break with the hands ... *7717
Cork chips, utilization of ... 7534
Corn, northern, the best ... 7846
Corvette Alexandrine ... *7771
Cottonwood tree, large ... *7891
Crane, steam, 35-ton ... *7742
Creeping of rails ... 7689
Creusot Works ... *7783
Creusot Works, visit to ... *7784
Croquettes, potato ... 7730
Croton Aqueduct, new ... *7517, 7519
Cruisers, merchant vessels as ... *7895
Currents, alternating, production *7841
Currents, electric safety, with .. 7602, 7677
Cutters, steam ... *7592
Cynanide of potassium ... 7756

D

Dark room, light for ... 7661
Deaf and dumb, alphabet of ... *7667
Deaf mutes, teaching, progress ... *7747
Deaths from electricity ... 7538
Defense of ports ... *7655
DeLome, Dupuy ... *7674
Density of the earth ... *7860
Developer, potash, improved ... 7756
Development, photographic ... 7738
Dinocrates' project ... *7789
Diphtheria, management ... 7649
Diseases of potatoes ... *7574, *7621
Diseases, nervous, progress in ... 7584
Distillation of sea water ... *7851
Distortion in photography ... 7853
Diving apparatus, Fleuss' ... 7786
Dock walls, construction ... *7495
Docks, at Tilbury ... *7815
Docks, dry timber ... *7767
Docks, Havre, wharf walls ... *7817
Dragon-fly, a large ... *7845
Drain pipes, obstruction ... 7556
Drawing tools, home made ... *7601
Dredges, American ... *7591
Dress goods, aniline dyes in ... 7505
Drumlins ... 7586
Dry plate process ... 7739
Drying wood ... *7649
Duck hunting, velocipede for ... *7717
Duel, royal ... *7811
Dumping car ... *7578
Dyeing yarns in vacuo ... *7726
Dyes, aniline, in dress goods ... 7505
Dynamite gun, experiments ... 7566
Dynamos, high tension current ... 7670

E

Eads, Capt., labors of ... 7640
Earth, mean density of ... *7860
Earthenware, jars for ferns ... *7878
Earthquakes ... 7766
Earthquakes in Andalusia ... *7781
Earthquakes in France ... *7618
Earthquakes in Spain ... *7652
Eclipse of August, 1886 ... 7890
Education, technical ... 7656
Eggs, how to cook ... 7730
Eggs, silkworm ... 7859
Elbow, right angle, drawing ... *7615
Electrified puppets ... *7716
Electric apparatus, thermo ... *7539
Electric charge of rain ... *7867
Electric currents, safety with .7612, 7677
Electric energy, distribution ... *7868
Electric engines ... 7538
Electric governor ... *7665
Electric insects ... *7712
Electric lamps, arc, Varley's ... *7839
Electric lamp, Gerard's ... *7857
Electric lamp, Cruto ... 7789
Electric lamp, Street's ... *7882
Electric light apparatus ... *7790
Electric light for fountains ... *7774
Electric light governor ... *7665
Electric light machinery ... *7868
Electric light railway ... *7809
Electric light regulator ... *7809
Electric lighting, cost ... 7808
Electric lighting, domestic ... *7744
Electric lighting of carriages ... *7868
Electric locomotive, Page's ... 7635
Electric pile, new ... *7635
Electric power, transmission ... *7554
Electric railway, coal mine ... *7580
Electric safety lamps ... 7712
Electric spark, photography of ... *7713
Electric speed indicator ... *7538
Electric stove ... *7743
Electric thermometer in medicine, *7539
Electric torpedoes in ports ... *7655
Electrical governor ... *7631
Electricity and magnetism ... 7790
Electricity and prestidigitation ... *7712
Electricity as a motor ... 7538
Electricity, deadly work of ... 7538
Electricity from clouds ... *7867
Electricity in varnish manufact ... *7856
Electricity of bodies ... *7716
Electricity, source of ... 7612, 7664
Electricity vs. boiler scale ... 7728
Electro-chemical drugs ... *7613, *7634
Electrolysis, reduction of ... *7558
Electrolytic works ... *7623
Electrometalling of copper, *7623, *7646
Electrotyping ... 7792
Elevator, Fontinette's ... *7608
Ellipses, apparatus to draw ... *7820
Emery wheels ... 7698
Emulsion, collodio-citro-chlo ... 7514
Engine, express, English ... *7575
Engine, express, on an ... 7861
Engine, fire, steam ... *7802
Engine, fireless ... *7708
Engine, gas, the ... 7720
Engine, governor, lot ... *7802
Engine, Harrington ... *7502
Engine, high speed ... *7672
Engine, traction ... *7527
Engine, Trevithick's ... *7497
Engines, balancing ... 7645
Engines, compound ... *7631
Engines, compound, triple ... 7848
Engines, electric ... 7528
Engines, gas ... 7800
Engines, heat, guns as ... *7834
Engines, portable, recent ... *7658
Engines, portable, wheels for ... *7550
Engines, tandem ... *7547
Engines, vapor binary ... 7593
Engineering inventions, since 1862 .. 7785, 7799
Engineering, military ... 7787
Engineering, subaqueous ... 7786
Entomology, applied ... 7588
Epidemic, Suspension Bridge ... 7520
Equivalents, app. to determine ... *7823
Erythroxylon ... 7861
Essence bouquet ... 7537
Essence bouquet extract ... 7760
Ether, some properties of ... 7841
Ether-spray microtome ... *7582
Etruria, ship ... *7895
Evolution, Buddhist theory ... 7652
Excavator, Gobert's ... *7564
Excavator, Osgood ... *7722
Expedition, Nile, British ... *7571
Expedition, Greely ... *7812
Expedition, relief, Greely ... 7748
Experiment, novel method ... 7662
Experiments in physics ... *7716
Exposition at Antwerp ... *7797
Exposition, New Orleans ... *7511
Exposure, correct, in photo-plates .. 7852
Exposures, photo, table of ... 7852
Explosions, bottle ... 7638
Explosive, a new ... 7705
Explosives, high, for war uses ... 7566
Express engine, English ... *7575
Express engine, on an ... 7861
Eyesight and civilization ... 7065
Eyes, compound ... 7844

F

Fabrics, stains in, removal ... 7515
Factory operatives, English ... 7844
Fat acids, conversion of ... 7824
Fats, examination of ... 7504
Felon, how to cure a ... 7750
Fencers, female ... *7747
Ferns, jars for ... *7878
Ferro-prussiate copying pro ... 7546
Fertilizers, potash in ... 7647
Fever, scarlet, oatmeal for ... 7750
Film mixtures ... 7904
Filter, a quick ... 7734
Filter, aeri- ... 7806
Filtering gelatinous mixtures ... *7514
Fingal's cave ... 7706
Fire engine, steam ... *7802
Fireproof building, New York ... 7884
Fireproof, fixing blocks ... *7600
Fish, tile, the ... *7622
Fishes, the orders of ... 7829
Flight, artificial ... *7826
Flora of bank notes ... *7813
Florida water ... 7760
Florists, designs for ... 7738
Flower market, Paris ... *7788
Flukes, evolution of ... 7830
Foods, digestibility of ... 7730
Forges, hall of, Creusot ... *7783
Formene, liquefaction of ... 7901
Fort Conger ... *7812
Forth Bridge ... *7627
Fossils of the West ... 7619
Fountains, illumination of ... *7774
Foundations, pneumatic ... 7786
Foundations, subaqueous ... *7495
Fowl cholera ... 7570
Fowls, Japanese ... *7782
Frangipanni ... 7537
Frangipanni extract ... 7760
Freezing microtome ... *7582
Frescoes found in Rome ... 7884
Fright, mental states from ... 7764
Fricton of lubricating oil ... *7544
Fruit canning, London ... 7633
Fuschias, Lye's ... *7734
Fuels, liquid and gaseous ... 7801
Furnace, Blanchard ... *7627
Furnace, blow pipe-flame ... *7527
Furnace, gas, heating ... 7534
Furnace, gas, laboratory ... *7514
Furnace slag and refining ... 7561
Furnaces, calcining ... 7601
Furnaces, smokeless ... *7805
Furnaces, welding, Swedish ... 7561
Fuse and shell, improved ... *7578

G

Galvanometer, Gray's ... *7857
Galvanometer, Rosenthal's ... *7805
Ganges, ship ... *7895
Garbage and mud receiver ... *7631
Gas, apparatus for making ... *7705
Gas brackets ... *7535
Gas, carbureting ... *7839
Gas, coal, for lethal purposes ... 7603
Gas engine, the ... 7720
Gas engines ... 7800
Gas furnace, heating ... 7534
Gas furnace, laboratory ... *7514
Gas-holder, accident ... *7761
Gas, illuminating ... *7716
Gas in the workshop ... *7674
Gas meter, the ... *7676
Gas, natural ... 7512, 7660
Gas, powder, pressures of ... *7834
Gases, anæsthetic, table of ... 7603
Gases, boiling points of ... 7807
Gases, liquefaction of ... 7503, 7558, 7807
Gases, liquefied, researches ... *7648
Gases, preparation, app ... *7616
Gate, wrought iron ... *7729
Gauge, pressure, gun ... *7850
Gear for anchors, Baxter's ... *7771
Geelong, ship ... *7895
Gelatine plates, intensification of ... 7697
Gelatino-bromide paper ... 7756
Gelatino-chloride plates ... 7533
Gelatinous mixtures, filtering ... *7514
Generation, spontaneous ... 7809
Generator, steam, Blanchard ... *7627
Generators, secondary, Gaulard-Gibbs, *7869
Geological survey, U. S ... 7730
Geology, practical studies ... 7618
Geranium extract ... 7760
Geranium, spirit of ... 7536
German school, overwork in ... 7519
Girders, stresses in ... *7711
Glass, soluble ... 7706
Glass, tempered ... 7897
Gluten determination ... 7764
Glycerine barometer ... *7894
Glycerine, nitro-, sugar ... 7705
Glycerine soap ... 7562, 7886
Gongs, signal ... 7496
Governor, electric ... *7665
Governor, electrical ... *7631
Governor, the cat ... *7809
Grain, preparation, apparatus ... *7514
Graphite in mineral, determ ... 7704
Gravity, constant, true ... 7714
Green Pond Mountain rocks, age ... 7877
Grooving machine ... *7882
Grove, Sir William R. ... *7842
Guard for shuttles ... *7851
Gun, air, experiments with ... 7566
Gun breech, removal from nose ... *7750
Gun, dynamite, experiments ... 7566
Gun, Gardner ... *7881
Gun, Hotchkiss ... *7881
Gun, Maxim ... *7881
Gun, Nordenfeldt ... *7881
Gun pressure-gauge ... *7850
Guns as heat engines ... *7834
Guns, Hotchkiss ... *7864
Guns, Krupp, for Spain ... *7847
Guns, machine ... *7880
Guns, Signal ... 7496
Gymnast, Bohlig ... *7844

H

Hakea laurina, shrub ... *7737
Hall of Palace of Justice, ... *7696
Hammer, steam, improved ... *7896
Hammer, steam, 100-ton ... *7783
Hammer telephone, The ... *7744
Handkerchief extracts ... 7759
Hanging, resuscitation after ... 7505
Hardness of Metals ... 7718
Harp, Æolian ... *7715
Hearing power, measurement ... 7830
Hearths, Swedish ... 7561
Heat engines, guns as ... *7834
Heat regulator ... *7594
Heating buildings by steam ... *7772
Heating cars ... *7632
Helianthuses ... *7732
Heliograph, double mirror ... *7580
Heliograph, Mancis ... *7579
Heliostat, Mangin's ... *7579
Heliostat, photo ... *7620
Heliotrope extract ... 7537, 7760
Helmets, 17th century ... *7776
Histological methods ... *7858
Home, Children's, Linden ... *7748
Honey soap ... 7887
Honeysuckle extract ... 7537
Horse of Kabah ... *7068
Horses, street car, care of ... 7653
Hose pipes, flow of water in ... 7495
Hot-water apparatus for cars ... *7632
Hatchings, ruler to draw ... *7851
Hotchkiss, Benj. B. ... 7695
House, Beckenham Park ... *7901
House of Parliament, Hungarian. *7637
House of thousand terrors ... 7680
Houses, Afghan ... *7806
Houses, country, sanitation ... 7539
Houses, healthy, Ewing on ... 7666
Hydatids, recent case ... *7904
Hydraulic elevator, Fontinette's .. *7608
Hydraulic propuls. of ships ... *7804
Hydraulic turntable ... *7641
Hydrogen, apparatus for ... *7705
Hydrogen, boiling point ... 7537
Hydrogen, dioxide ... 7843
Hydrodynamic researches, Bjerknes, *7791 *7840
Hygiene, Nature's ... 7866
Hyperbolas, to draw ... *7820
Hypnoscope, the ... *7556

I

Iceboat races ... *7689
Iceland ... 7557
Iconometer, photographic ... *7583
Illumination ... 7801
Immortelles, wreaths of ... 7836
Indians, Mohawk, pottery of ... 7667
Indicator, steam engine ... *7530
Indicators, speed, electric ... *7538
Induction and conduction ... *7745

Inebriety, mental contagion in ... 7569
Insane, provision for, progress ... 7805
Insane, State provision for ... *7794
Inscriptions, Maya, Uxmal ... *7573
Insecticides ... 7589
Insects, electric ... *7712
Insects, winged, fossil ... 7828
Insects, winter and the ... *7859
Insurance, life, management ... 7522
Intensification of gelatine plates ... 7809
Interoceanic ship railway ... *7639
Inventions, eng. since 1862 ... 7785, 7799
Inventors' Institute ... 7506
Inversion of sugar ... 7513
Iron and steel ... 7799
Iron as a battery element ... 7808
Iron, Bower-Barff ... 7625, 7895
Iron, cast, and remelting ... 7580, 7707
Iron, cast, to harden ... 7598
Iron castings, sound ... 7699
Iron pile planks ... *7495
Iron, preservation of ... 7625
Iron printing ... 7707
Iron rust, removal of ... 7515
Iron vapors, spectroscope exam ... 7526
Iron works, Krupp ... 7659
Isochromatic photography ... *7853
Italy, avalanches in ... *7701

J

Jack, steam, history ... 7848
Jack, steam, the old ... *7742
Jars for ferns ... *7878
Jasmine, essence of ... 7536
Jessamine extract ... 7760
Jet ventilator, Korting's ... *7706
Jetties, Reunion Island ... *7659
Jockey club extract ... 7537, 7760
Joints, steam and water, cement ... 7699
Jupiter, surface markings of ... 7829

K

Khiva, ship ... *7896
Kibitka, Afghan ... *7808
Kitchen soap ... 7886
Kola nut, the ... *7606
Krupp works ... 7659

L

Labor and wages in America ... 7683
Laboratory gas furnace ... *7514
Laboratory wire apparatus ... *7863
Lamp, albo-carbon ... *7830
Lamp, arc, Varley's ... *7839
Lamp, electric, Gerard's ... *7857
Lamps, electric, portable ... *7712
Lamps, incandescent, Cruto ... 7789
Lamp, Street and Maquaire ... *7822
Lamp, Wenham's ... 7709
Land of Nimrod ... 7772
Landscapes, human face in ... *7789
Lantern transparencies ... 7707
Larynx, photographing the ... *7555
Lathe attachment, lens ... *7897
Launch, screw, fast ... *7818
Launches, steam ... *7592
Laundry soap ... 7886
Lead-case press ... *7761
Lead, its properties and uses ... 7560
Lead, soldering of ... 7601
Leaf-eating ants ... 7699
Leather, chair, embossed ... *7610
Leaves, forms of ... 7795
Lemon, essence of ... 7536
Lens making ... *7862
Lethal chamber ... *7603
Lick, James ... *7620
Lick Observatory ... *7620
Life, extinction of, painless ... 7802
Life insurance, management ... 7522
Life, lower and forms, researches ... *7508
Lift, mud and garbage ... *7631
Light, action on silver chloride ... 7779
Light apparatus, electric ... *7790
Light, diffused, photometer for ... *7870
Light, electric, domestic ... *7744
Light, electric for fountains ... *7774
Light, electric, governor ... *7580
Light, electric, machinery ... *7898
Light, electric, railway ... *7809
Light, electric, regulator ... *7809
Light, loss of by shades ... *7674
Light, non-actinic ... 7661
Light, photo printing ... 7727
Light, pillar, for workshops ... *7874
Light, standard, absolute ... 7558
Light, standards of ... *7726
Light, the Trenham ... *7700
Light, water gas ... *7871
Lightships and captive balloons ... 7880
Lilac extract ... 7537
Lily of Valley extract ... 7537
Liquefaction of formene ... 7901
Liquefaction of gases ... 7503, 7508, 7807
Liquefaction of nit. oxide ... 7901
Liquefied gases, researches ... *7848
Liquids, boiling point ... 7807
Liquids, specific heat of ... 7883
Locomotive Decapod ... *7836
Locomotive, electric, Page's ... 7635
Locomotive, express, English ... *7775
Locomotive on Righi Railroad ... *7672
Locomotive, tank ... *7837
Locomotive whistles ... 7496
Locomotives, compressed air ... 7852
Locust, migratory, the ... *7685
London, subway, a ... *7632
London Times, centenary ... 7614
Looms, improvement in ... *7809
Louvain, prison of ... 7571
Lubricating oils ... *7544, 7699
Lubricator, sight feed ... *7761
Lubricators, rattan ... *7576
Lubricants, real value of ... 7871
Lusitania, ship ... *7898
Lyonnaise potatoes ... 7730
Lyre, birds, notes on ... 7588

M

Machine guns ... *7880
Machine guns, Hotchkiss ... *7804
Machinery, Forth Bridge ... *7828
Magnesia mine, a great ... 7755
Magnet, new application ... *7556
Magnetic field, chemic action ... 7830
Magnetic phantoms, fixing ... *7503
Magnetism and electricity ... 7790
Magnolia extract ... 7537
Mammals, placental phylogeny ... 7890
Mandrel, expanding ... *7804
Map of ship railway ... *7641
Map, topographical, of U. States ... 7751
Maps, how to copy ... 7546
Marble Cave ... 7586
Marble group, Canova ... *7901
Marble panels, Roman ... *7884
Mardt Tunnel ... 7595
Marie Stuart extract ... 7760
Market buildings, movable ... *7798
Market, Cattle, Vienna ... *7651
Market, Flower, Paris ... *7788
Maya alphabet ... 7572
Maya art ... *7782
Meals, management ... 7587
Measures, Metric and British ... 7662
Mechanic arts, foreign, etc ... 7656
Mechanics, amateur ... *7628
Melloco tubers ... *7527
Membrana tympani ... *7585
Mental contagion in inebriety ... 7569
Mental states from fright ... 7764
Meridian, the world's first ... 7553
Metal, sheet, art in ... 7897
Metal elasticity of ... 7743
Metals, hardness of ... 7775
Metals, volatility of ... 7627
Metal, yellow, new ... 7776
Metallic vapors, spectra ... 7560
Meter, gas, the ... *7682
Meter, steam ... *7772
Meters, water ... *7558

Methylene ... 7662
Metric and British measures ... 7662
Mexican, ship ... *7895
Mexico in the Bronze age ... 7781
Microbes, cholera ... *7586
Microbes, culture of ... *7845
Micro-organisms and chem. change ... 7763
Microphone, thermo-, the ... 7774
Microphotoscope, the ... *7564
Microscope condenser ... *7582
Microscopic photography ... 7707
Microtome, freezing ... *7582
Milk sugar manufacture ... 7583
Military ballooning ... 7770
Military electric light ... *7790
Military engineering ... 7787
Military telegraph ... *7867
Military telegraphy ... *7579
Millefleurs extract ... 7537, 7760
Milling machine, new ... *7838
Milling of ores ... 7601
Mind, human, genesis ... 7622
Mine, magnesia, a great ... 7755
Mine pumps ... 7849
Mines, ventilator for ... *7706
Mineral acids, solid ... 7560
Minerals, graphite in, determ ... 7704
Minute in Nature, study of ... *7508
Mohawks, pottery of ... 7667
Moisture, effect on refraction ... 7601
Monkeys, the ways of ... 7891
Monument, Washington, 7515, 7598, *7650
Motors, hints on ... *7872
Motors, influence of sand on ... 7576
Motor for sewing machine ... *7836
Motor, soda ... 7800
Motor, spring, a ... 7711
Motors, spring, for vehicles ... *7548
Motors, sun and tide ... 7800
Moulding porcelain ... *7726
Mud and garbage receiver ... *7631
Mule, spinning, improved ... *7543
Mural painting at Kabah ... *7809
Musk, tincture ... 7536
Mustard, cultivation of ... 7813
Mutes, deaf, teaching ... *7747

N

Nature's hygiene ... 7666
Navigation, aerial ... 7800, *7816, 7864
Navigation, aerial, apparatus ... *7826
Navigation, capstan ... *7622
Navigation, inland, Europe ... 7851
Nectria solani ... *7621
Negatives, compound ... 7707
Nepaul, ship ... *7895
Neroli spirit ... 7536
Nervous diseases, progress in ... 7584
Neutraline ... *7740
Nevada, salt in ... 7619
New mown hay extract ... 7537
New Orleans Exposition ... *7511
Niagara cantilever bridge ... *7687
Nile expedition, British ... *7511
Nitric oxide liquefaction ... 7901
Nitrification, notes on ... 7504
Nitroglycerine, sugar ... 7705
Nose, removal of gun breech ... *7750
Nut, kola, the ... *7606
Nuts, facing, mandrel for ... *7804

O

Oak, Japanese, new ... *7878
Oak phylloxera ... *7814
Oatmeal for scarlet fever ... 7750
Observatory, Lick ... *7620
Ocean water, properties ... 7662
Offices, Sheffield ... *7754
Oil, Brassica ... 7719
Oil, cabbage ... 7719
Oil, Camellia ... 7779
Oil, camphor, Japanese ... *7552
Oil, effect in boilers ... *7803
Oil for stopping breakers ... 7592
Oil, tea ... 7793
Oil, wood ... 7779, 7794
Oil, chinese, fixed ... 7793
Oil, Japanese, notes on ... 7793
Oils, lubricating ... *7544, 7699
Old age, suspension of ... 7825
Omelets, how to make ... 7730
Opening machine, asbestos ... *7741
Optical telegraphy ... *7579
Orange flower extract ... 7537
Orange flowers, essence ... 7536
Ores, milling of ... 7601
Organ for St. Andrew's ... *7533
Organisms, minute, study of ... *7508
Originality, courage of ... 7795
Otoscope, Rattel's ... *7794
Oven, steam, constant level ... *7514
Overwork in German schools ... 7519
Oxide, nitric, liquefaction ... 7901
Oxygen in water, estimation ... *7513

P

Painting, mural, at Kabah ... *7809
Palace, Babylonian ... 7798
Palace of Justice, Hall of ... *7697
Paleozoic insects ... 7828
Palm soap ... 7886
Panama Canal, dredgers in ... *7591
Panels, marble, Roman ... *7884
Pantelephone, De Locht's ... *7857
Paper, albumenized, floating ... 7532
Papers at National Academy Sci ... 7728
Paper, expansion, in photography ... 7853
Paper, gelatino-bromide ... 7756
Paper, salicylic ... 7779
Paraffin, liquid ... 7843
Park, City Hall, Vienna ... *7810
Pastes, scouring, analysis ... 7495
Pasteur's work ... *7570
Patchouly extract ... 7537, 7760
Patent Office examinations ... 7778, 7795
Pavements, street ... 7594
Pavement of Kansas City ... 7889
Pea, sweet, extract ... 7760
Perfumes, formulas for ... 7536
Perfumes for soap ... 7887
Perfumer's manual ... 7759
Permeability, experiment in ... *7890
Petroleine ... 7777
Phantoms, magnetic, fixing ... *7503
Phenix cock of Japan ... *7739
Phosphates from slag ... 7661
Phosphorus, carbon in ... 7616
Photographic development ... 7738
Photographic iconometer ... *7702
Photo. surfaces, sensitiveness ... 7546
Photographing the larynx ... 7555
Photographs, vitrified ... 7533
Photography, astronomical ... 7728
Photography, distortion in ... 7756
Photography, isochromatic ... *7853
Photography of electric spark ... *7713
Photography, microscopic ... 7707
Photo-heliostat ... *7620
Photometer for diffused light ... *7870
Photometrical standards ... *7726
Photo plates, correct exposure ... 7852
Photo printing light ... 7727
Photoscope, micro- ... *7564
Photo-tricycle apparatus ... *7727
Phylloxera at Turin Exhib ... 7631
Phylloxera, oak ... *7814
Phylloxera, treatment of ... *7521
Physical papers by Sir W. Thomson ... 7567
Physics of tenuity ... *7902
Physics without apparatus *7716, *7880
Piedmont, avalanches in ... *7701
Pile element, iron as ... 7808
Pile, new, Hospitalier's ... *7744
Pile, O'Keenan's ... *7835
Pile planks, iron ... *7495
Pile, Warnon's ... *7744
Pine, Lambert's ... *7822
Pine, stone, the ... *7797
Pink, sweet, extract ... 7760
Pinnaces, steam winch ... *7723
Pipes, drain, obstruction ... 7556
Pipes, heat, flow of water in ... 7666

Pipes, water, galvanized iron ... 7764
Pistol ball, extr. from brain ... *7874
Pittsburg, steamer ... *7880
Plaiting machine ... *7851
Plane surfaces, errors in ... *7724
Plane, trochoided, the ... *7826
Planetary wheel trains ... *7497, *7690
Planimeter, rolling ... *7756
Plans, how to copy ... 7456
Planting trees, directions ... 7737
Plants propagated by cuttings ... 7669
Plants, sex regulation ... 7893
Plastering, hints on ... *7872
Plateau's film mixture ... 7904
Plates, gelatino-chloride ... 7533
Platinum, fusion of ... 7749
Plum, Japanese, new ... *7765
Plumbing test, a ... 7719
Pneumatic foundations ... 7786
Polishing machine for shoes ... *7677
Pomades, floral ... 7759
Pontoon and railway cradle ... *7643
Pontoon bridge, Guatemala ... *7565
Poonah, ship ... *7895
Population of United States ... 7812
Porcelain, moulding ... *7726
Port of Reunion Island ... *7659
Portable engines, recent ... *7658
Portraits, silhouette ... *7716
Ports, defense by torpedoes ... *7655
Potash cold soap ... 7886
Potato, Mexican ... 7647
Potassium cyanide ... 7756
Potassium, sulpho-cyanide ... 7704
Potato disease ... *7574, *7621
Potatoes, how to cook ... 7730
Pottery, Mexican ... 7782
Pottery of the Mohawks ... 7667
Powder gas pressures ... *7834
Power, electric, transmission ... *7554
Power, transmission ... 7800
Press, lead-case ... *7761
Pressing machine, cloth ... *7662
Pressure-gauges, grand ... *7850
Pressure, warmth, coldness ... 7883
Prestidigitation and electricity ... *7712
Printing light, photo ... *7727
Printing, iron ... 7707
Prints, blue ... 7707
Prison of Louvain ... 7571
Propeller, car, Cole's ... *7548
Propell'r steamer, shallow draught *7818
Protoplasm ... *7701
Psychography ... 7888
Pump, Chinese ... *7672
Pump, Griffin ... *7597
Pumping machinery ... 7849
Puppets, electrified ... *7716
Pyramids, great ... *7749

Q

Quercus serrata ... *7878
Quinces, how to grow ... 7813

R

Races, ice boat ... *7683
Rails, creeping of ... 7689
Rails, street, tests for ... 7847
Railroad building in tropics ... *7565
Railroad facilities, modern ... 7768
Railroad, fastest runs ... 7769
Railroad, Righi ... *7671
Railroad tunnels, longest ... 7802
Railroads, cable and surface ... *7769
Railway bridge, Guatemala ... *7565
Railway, Canadian Pacific ... 7721
Railway, electric, coal mine ... *7580
Railway electric light ... *7809
Railway, elevated, plan for ... *7785
Railway of Reunion Island ... *7659
Railway, ship, Tehuantepec ... *7639
Railway, single-rail ... *7598
Railway, suspended ... *7566
Railways, cable, Corning's system *7769
Rain, falling, electric charge ... *7867
Ramie, cultivation of ... 7573
Rattan lubricators ... *7576
Reel, mathematical ... *7818
Receiver, mud and garbage ... *7631
Recorder, sunshine ... *7717
Reduction by electrolysis ... 7558
Regulator, heat ... *7594
Regulator for electric light ... *7809
Relay for telephone calls ... *7808
Relief expedition, Greely ... 7748
Remelting cast iron ... 7707
Resilience of steel ... 7743
Resuscitation after apparent death ... 7505
Retorts for ammonia, man'f. *7758, *7777
Reunion Island, new port ... *7659
Revolution counter, electric ... *7538
Richardson, Benj. Ward ... *7764
Rifle expert, a ... 7877
Righi railroad ... *7671
River improvements ... 7786
Rockets, signal ... 7496
Rolls, stamps versus ... *7601
Roller grinding machine ... *7882
Rome, frescoes found in ... 7884
Rondeletia extract ... 7537
Roofing tiles ... 7509
Room, the largest ... 7652
Roofs, asphalt ... 7885
Rose, essence of ... 7536
Rose, extract of ... 7760
Rosetta, ship ... *7805
Rosin film mixture ... 7904
Rot, dry, in potatoes ... 7621
Rot, wet, of potatoes ... 7621
Royal duel ... *7811
Ruler for hatching ... *7851
Rum, bay ... 7761

S

Saint Etienne tramways ... *7547
Salicylic paper ... 7779
Salt in Nevada ... 7619
Sand, influence on mortar ... 7576
Sand soap ... 7562
Sanitary cooking ... 7730
Sanitary matters, brief ... 7729
Sanitation ... 7539
Santal, spirit of ... 7536
Saponification by neutrals ... 7584
Saratoga potatoes ... 7730
Scale in boilers, electricity vs ... 7728
Scarlet fever, oat meal for ... 7750
School, Central, Paris ... *7507
School, watchmaking ... *7677
Schools, German, overwork in ... 7519
Schule, Carl W ... 7616
Science, Assyrian ... 7572
Scientific amusements ... *7716
Scouring pastes, analysis ... 7495
Screw launch, fast ... *7818
Sculpture, bronze casting applied ... 7872
Sea-water, distillation ... *7851
Sea-water, properties ... 7662
Sections, how to cut ... 7858
Seed, Cedron ... 7806
Seed, mustard, growing ... 7813
Seismograph, new ... *7793
Selenium actimeters, new ... 7727
Selenium cells, Fritts' ... 7854
Senkrah, Arma, violinist ... *7526
Septic organism, a new ... 7858
Sewerage, a plan for ... 7887
Sewers, cleaning ... *7585
Sewing machines motor ... *7836
Sex, causes of ... 7893
Sex, regulation of ... 7893
Shades, glass, loss of light by ... *7674
Shale, ammonia from ... *7758, *7776
Shaving cream ... 7886
Sheffield corner, a ... *7754
Shell and fuse, improved ... *7578
Ship Alexandrine ... *7771
Ship of war Colossus ... *7799
Ship railway, Tehuantepec ... *7636
Ship, war, Agamemnon ... *7607
Ships, growth of weeds on ... 7670

Ships, hydraulic propuls ... *7804
Ships, light, and balloons ... 7880
Ships, steam, dimensions of ... *7593
Ships, torpedo ... 7719
Ships, water chambers for ... *7803
Shoes, machine to polish ... *7677
Shooting, experts in ... *7877
Shoring of buildings ... *7752
Shores, various forms of ... *7753
Shrub, greenhouse, a ... *7737
Shuttle guard ... *7851
Sideboard, Chippendale ... *7503
Sight feed lubricator ... *7761
Signals, sound ... *7496
Silhouettes ... *7716
Silicates, natural ... 7829
Silk warping machine ... *7699
Silkworm disease ... 7570
Silkworm eggs ... *7859
Silliman, Benjamin ... 7695
Silver chloride, action of light on ... 7779
Sims, James Marion ... *7749
Siren, the ... 7497
Skeleton of a bear ... *7718
Slag, blast-furnace, refining ... 7561
Slag cement ... 7698
Slag, phosphates from ... 7661
Sled, coasting, N. England ... *7504
Sluices, Dutton ... 7550
Smelting plant, rapid ... *7900
Smilax aspera ... *7637
Soap bubble, the ... 7809
Soap bubble experiments ... *7902
Soap, recipes for ... 7886
Soap, sand and transparent ... 7562
Society, tribal, organization ... 7889
Soda boiler, the ... 7800
Soda engine, fireless ... *7708
Solar eclipse of Aug. '86 ... 7830
Soldering of lead ... 7601
Soil, moisture of ... 7558
Sound signals ... *7496
Sound, theory of, fallacy ... 7500
Sound, true velocity of ... 7883
Southwell Cathedral ... *7877
Spark, electric, photographed ... *7713
Speech, telephonic transmiss ... *7820
Speed indicators, electric ... *7538
Spectra of metallic vapors ... 7560
Spectra, spark, of chlorides ... 7627
Spinning mule, improved ... *7543
Sponge as poultice carrier ... 7875
Spontaneous generation ... 7809
Spring motor, a ... 7711
Spring motor for vehicles ... *7548
Spring wheels ... *7550
Stables, construction of ... 7610
Stains in fabrics, removal ... 7515
Staith, coal, Butler's ... *7515
Stamps, ore, wear and tear ... 7602
Stamps vs. rolls ... 7601
Station of Greely party ... *7812
Station, torpedo ... *7656
Statuary of Vienna ... *7854
Statuary, zinc ... *7697
Statue of Achilles ... *7754
Statue, Wallace ... *7599
Steam boilers ... 7800
Steam catamaran ... *7529
Steam crane, 35-ton ... *7742
Steam cutters ... *7592
Steam, efficiency of ... 7657
Steam engine, Harrington ... *7502
Steam engine, high speed ... *7672
Steam engine indicator ... *7530
Steam engine, traction ... *7527
Steam engine, Trevithick's ... *7497
Steam engine, balancing ... 7645
Steam engines, compound ... *7631
Steam engines, portable ... *7658
Steam engines, tandem ... *7547
Steam engines, triple ... 7848
Steam fire engine ... *7802
Steam generator, Blanchard ... *7627
Steam, generators, feeding ... *7707
Steam hammer, improved ... *7896
Steam hammer, 100-ton ... *7783
Steam, heating buildings by ... *7772
Steam jack, history ... 7848
Steam jack, the old ... *7742
Steam joints, cement ... 7699
Steam launches ... *7592
Steam meter ... *7772
Steam oven, constant level ... *7514
Steam pumps ... 7850
Steam, specific heat ... 7883
Steam trap, improved ... *7723
Steam winch for pinnaces ... *7723
Steam yachts ... 7718
Steamboat equipm't of war vessels, 7723
Steamer Pittsburg ... *7880
Steamer, propeller, fast ... *7818
Steamships, Atlantic, great ... *7593
Stearic acid apparatus ... *7563
Steel and iron ... 7799
Steel boiler plates ... 7815
Steel, compressed ... 7800
Steel process, Clapp-Griffiths ... 7825
Steel, punching holes in ... *7551
Steel rails, tests for ... 7847
Steel, resilience of ... 7743
Still, constant level ... *7514
Storm glass, the ... 7893
Stove for wood-drying ... *7649
Stove, electric ... 7743
Stoves, cement for ... 7699
Street pavements ... 7574
Stresses in girders ... *7711
Street car horses, care of ... 7653
Sturgeon slaughter house ... *7810
Subway, London ... *7632
Sugar, invention of ... 7513
Sugar of milk, manufacture ... 7583
Sugar nitro-glycerine ... 7705
Sugar-sand, manufacture ... 7583
Sulphide of carbon ... *7704
Sulpher, burner for ... *7704
Sulphurous acid ... *7704
Sumac ... 7615
Sun and tide motors ... 7800
Sunflowers ... *7732
Sunshine recorder, a ... *7717
Surfaces, plane, errors in ... *7724
Survey, Geological, U. S ... 7730
Suspension bridge epidemic ... 7520
Sweden, coast of, rise ... 7511
Sweet brier extract ... 7760
Swiveling wheel ... *7835
Synchronism ... *7762

T

Table, rapping ... *7712
Tanekaha bark ... 7605
Tank, locomotive ... *7837
Tannin ... 7582
Tea, Japanese ... 7647
Tea oil ... 7793
Technical education ... 7656
Tehuantepec ship railway ... *7639
Telegraph conductors, new ... *7762
Telegraph, optical ... *7579
Telegraph, military ... *7867
Telegraph wires, city ... 7878
Telegraphs ... *7579
Telephone cables, new ... *7762
Telephone calls, relay ... *7808
Telephone, hammer, the ... *7744
Telephone, Neumayer's ... *7538
Telephone system, Naglo's ... *7857
Telephones in America ... 7679
Telephonic transmission of speech *7820
Telescopes, improvements in ... *7735
Telescopes, progress in ... *7735
Temperature, earth's, decrease ... 7619
Temperature, high, phenomena ... 7807
Tempering glass ... 7874
Tentering machine, cloth ... *7662
Tenuity, physics of ... *7902
Thames, bridge over, design ... *7879
Thames bridge, proposed ... *7888
Thermodynamics, new ... 7883

Thermo-electric apparatus ... *7539
Thermometer, electric ... *7539
Thermometer, Guichard's ... *7761
Thermomicrophone, the ... 7774
Theseus and Centaur ... *7901
Thread, reel for ... *7818
Thunderstorms, origin of ... 7714
Tide and sun motors ... 7800
Tilbury docks ... *7815
Tile fish, the ... *7622
Tiles, roofing ... 7579
Timber dry dock ... *7767
Times, London, centenary ... 7614
Tissues, mounting ... 7858
Tobacco, Japanese ... 7647
Toilet soaps ... 7886
Tonka, tincture ... 7536
Tools for lenses ... *7897
Tooth wash, tonic ... 7761
Torpedo boats in war ... 7896
Torpedo boats, winch for ... *7723
Torpedo defense of ports ... *7655
Torpedo observing station ... *7656
Torpedo, Paulson's ... *7673
Torpedo ships ... 7719
Tower bridge, design ... *7879
Tower, 1,000 foot ... *7577
Toys, improvised ... *7715
Tracings, how to copy ... 7546
Trains, railroad, fastest ... 7768
Tram cars, swiveling wheel for ... *7835
Tramways, St. Etienne ... *7547
Transfusion apparatus ... *7568
Transparent soap ... 7887
Transparencies, lantern ... 7707
Transparent soap ... 7562
Trap, steam, improved ... *7723
Tree, cottonwood, large ... *7891
Tree planting, directions ... 7737
Tribe, organization of the ... 7889
Tricycle, photo-, apparatus ... *7727
Trochoided plane, the ... *7828
Trumpets, signal ... 7497
Tuberose, essence ... 7536
Tuberose extract ... 7760
Tunnel, Arlberg ... 7801
Tunnel, Channel ... 7598
Tunnel, Mardt ... *7595
Tunnels, construction of ... 7786
Tunnels, railroad, longest ... 7802
Turntable, floating ... *7644
Turntable, hydraulic ... *7641
Twist, philosophy of ... *7819
Tympanic membrane, the ... *7585
Type-setting by machinery ... 7614

U

Umbria, ship ... *7895
United States in 1780 and 1880 ... 7811
United States, population ... 7812
United States, Preece on ... 7678
University buildings, Vienna ... *7512
Upper ten extract ... 7537

V

Vacuum apparatus, new ... *7839
Valve, steam, reducing ... *7772
Vanilla, tincture ... 7536
Vapor engines, binary ... 7593
Vapors, metallic, spectra ... 7560
Varnish, black ... 7718
Varnish manufact., electricity in. *7856
Varnishes, car, testing ... 7502
Vaseline ... *7740
Vegetable liquids, ash of ... 7606
Vehicles, spring motors for ... *7548
Velocipede, aquatic ... *7717
Ventilation without draught ... 7753
Ventilator, jet, Korting's ... *7706
Veranda, ornamental ... *7552
Verbena extract ... 7537, 7760
Vertebrata, fossil, of Brazil ... 7829
Vessels, merchant, as cruisers ... *7895
Viaduct Blaauw Krantz ... *7719
Victoria regia ... *7590
Villas at Clewer ... *7885
Violet extract ... 7760
Violets, essence ... 7536
Vitivert, spirit of ... 7536
Volatility of heated metals ... 7627
Voltameters, colorimetric ... *7568

W

Wages and labor in America ... 7683
Wagon, tipping ... *7578
Wallace statue ... *7599
Walls, wharf of Havre docks ... *7817
Walter, John ... 7614
Warmth, coldness, pressure ... 7883
War ship Agamemnon ... *7607
War ship Colossus ... 7799
War, torpedo boats in ... 7896
War vessels, steamboat equipment ... 7723
Warping machine, silk ... *7699
Washington Monument, 7515, 7598, *7650
Watchmaking, school of ... *7677
Water, action on double salts ... 7542
Water chambers for ships ... *7803
Water clock ... *7673
Water, drinking, purification ... 7842
Water, drinking, zinc in ... 7638
Water heaters ... *7633
Water gas incandescent light ... *7871
Water joints, cement for ... 7699
Water meters ... 7558
Water, oxygen in, estimation ... *7513
Water pipes, galvanized iron ... 7764
Water purifying apparatus ... *7887
Water, purification of ... *7899
Water, sea, distillation ... *7851
Water, sea, properties ... 7662
Water supply ... 7801
Water, underground ... 7556
Waterproof paste cement ... 7699
Waves, oil on ... 7592
Weeds, growth on ships ... 7670
Welding furnaces, Swedish ... 7561
Well, artesian, Fort Scott ... 7508
Wells, artesian, Pomona ... *7521
Whale, stranded, a ... *7766
Wharf walls of Havre dock ... *7817
Wheel, swiveling, Tenwick's ... *7835
Wheel trains, planetary ... *7497, *7690
Wheels, car, casting ... *7712
Wheels, emery ... 7698
Wheels, iron and wood combined. *7550
Wheels, spring ... *7550
Whistles, locomotive ... 7496
Whooping cough, management ... 7649
Winter and the insects ... *7859
Winch, steam, for pinnaces ... *7723
Wine, Pasteur's researches ... 7570
Winter scenes on the Brocken ... *7780
Wire apparatus for laboratories ... *7863
Wire, copper, drawing ... *7516
Wires, telegraph, city ... 7878
Wood, drying ... *7649
Wood, influence on architecture ... 7751
Wood oil ... 7779, 7794
Wood, preservation of ... 7787
Wood, ultimate products ... 7870
Wool, wood ... *7615
Workshop, gas in the ... *7674
World's first meridian ... 7553
Wreaths of immortelles ... *7836

X

Xylophone, the ... *7792

Y

Yachts, stability and speed ... *7832
Yachts, steam ... 7718
Yarns, dyeing ... *7726
Yellow metal, new ... 7776
Ylang, spirit of ... 7536
Ylang Ylang extract ... 7760
Yucatan, ruined cities ... *7666

Z

Zambesi, ship ... *7895
Zinc in drinking water ... 7638
Zinc statuary ... *7697